‘Complex and confusing’: the language demands of science texts.

Abstract

Background: In many classrooms, science textbooks remain a significant tool, functioning in some instances as the de facto curriculum and influencing pedagogical practices. Such conventions are more noticeable in the science classrooms of developing countries, like Jamaica, because of a chronic shortage of specialist science teachers and the scarcity of equipment for laboratory activities. Given the centrality of science textbooks and their ubiquitous use, it is important that they meet the requirements of the learners; that is, they should be engaging and comprehensible by students, with or without their teachers’ supervision. Yet, much empirical evidence indicate that the language of science textbooks remains incomprehensible to many students.

Purpose: This paper attempts to ascertain the extent to which the language of a popular science textbook is accessible to Jamaican students.

Sample: A purposive sampling technique was used to determine the sample which consisted of 450 Year 7 students drawn from five secondary school types in Jamaica. These schools were selected to ensure diverse range of participants. In addition, sub-samples of 30 students and 18 teachers from the five school types were selected for focus groups and interviews.

Design and methods: This study combined readability formulae, cloze tests, focus groups and individual interview research methods. Such an approach not only afforded triangulation that enhanced the credibility of the findings but also provided interesting contrasting perspectives to address the research question.

Results: The empirical evidence from the cloze test and readability index indicates that the textbook studied was challenging and demanding for the target audience. Data from the interviews indicates that the language used in the construction of science content knowledge in textbooks was the main source of difficulty for many Jamaican students. The major areas of language difficulties were related to the unsystematic use of scientific terminologies and the overuse of complex sentences. The interview data also indicates that many teachers expressed reservation about the impersonal nature of scientific language used in the science textbook.

Conclusion: A Vygotskyan scaffolding intervention framework which includes using a smaller number of key vocabulary words is recommended.

Introduction

A major goal of any country's science curriculum is to help its citizens to engage with important questions concerning science-related issues and contribute to sustainable development regardless of their social background. However, this goal remains in the 'pipeline' for many science learners, especially in developing countries like Jamaica. Unfailingly, students' unacceptable performance in science and science related examinations seems to validate such observations. According to data from the Ministry of Education in Jamaica (2017), between the years 2010 and 2016 over half of the students who sat biology, chemistry and physics for the Caribbean Secondary Education Certificate (CSEC) failed to achieve acceptable grades of I–III. For integrated science, the same worrying trend is apparent, with only 47% of students achieving acceptable grades over the same period. Unquestionably, these results paint a lugubrious picture of science education in Jamaica.

Various reasons are attributed to these poor performances and include a dearth of specialist science teachers and the scarcity of equipment for effective laboratory activities (Webb and Karatjas 2018). Incontrovertibly, these arguments have both currency and relevancy in the debate concerning the state of science education in Jamaica. However, what is not always so obvious is the barrier that language poses to meaning-making in science classrooms.

Prominent scholars such as Wellington and Osborne (2001) have suggested that language is one of the main barriers to meaning-making in science, rather than the content itself. There is much evidence to support this position. For example, Gardner's (1972) assessment of the language proficiencies of students in Australia showed that some of the most abundantly used words in science discourse were difficult for the students to comprehend. Similar findings were reported by Cassels and Johnstone (1985) and later by Pickersgill and Lock (1991) in their ground-breaking UK study of some of the most problematic words that confused pupils learning science. Cassels and Johnstone (1985, 1) noted that:

> the problem lay, not so much in the technical language of science, but in the vocabulary and usage of normal English in a science context. Pupils and teachers saw familiar words and phrases which both 'understood', but the assumption that both understandings were identical was just not tenable.

They lamented that such difficulties of word meaning provide fruitful terrain for “loose reasoning and strange conclusions” (Cassels and Johnstone 1985, 14).

Correspondingly, the meaning-making process is made more problematic by the fact that words, in themselves, do not carry exclusive meanings. Words are unsurprisingly polysemous, developing different hues of meaning as the context of usage changes (Mortimer and Scott 2003). In relation to this point, a growing number of researchers have highlighted some of the challenges that students encounter with polysemous words in a variety of contexts and cultures. Noteworthy among these studies is Song and Carheden’s (2014) evaluation of how post-16 students understand selected chemistry dual meaning vocabulary pre and post instructions. These authors reported that even after instructions, the everyday meanings of dual meaning vocabulary were so unremittingly entrenched in students’ consciousness that they struggled to retain their scientific meanings. Such poor retention was attributed, in part, to the students’ infrequent usage of dual meaning vocabulary in meaningful contexts. Similar findings were also reported by Jasien (2010, 2011) in his examination of the challenges that students face when contextualising science terminologies. These findings have important implications in the Jamaican context, where commonly used scientific terms can signify different things for school science learners, who then have to internalise several different meanings of a given idea, none of which are in their first language.

More recently, scholars have directed their attention on the linguistic pressures placed on students who are learning science through a ‘foreign language’ (see, for example, Poza 2018). There is now broad agreement among researchers that such learners encounter considerable problems when learning science through ‘foreign languages’, as they not only have to learn the science curriculum and scientific skills within rigid boundaries of discursive science norms, but also the social practices of the language. What has also emerged from these studies is that many teachers show little or no awareness of linguistically and culturally responsive science pedagogies, and work on the premise that ESL learners must acquire the dominant language of instruction before engaging in science content learning (Lee, Quinn and Valdes 2013). This is despite the overwhelming research evidence which suggests that ESL learners acquire content learning more effectively when they make use of their full linguistic repertoire (Garcia 2009) and when new content is situated in a familiar context related to students’ prior experiences (Martinez-Alvarez 2017). The above-mentioned researches are particularly salient for bilingual countries like Jamaica. Although I have described Jamaica as ‘bilingual,’ the form that language takes and how it is used is extremely complex and has created a dilemma for science instruction. A brief description of the Jamaican linguistic environment is provided below.

Language in Jamaica

The Jamaican linguistic environment is probably best described as a ‘diglossia (Ferguson 1959), in which a language of high status, Jamaican Standard English (JSE), and language of a low status, Jamaican Creole (JC), coexist, and are appropriate in different social contexts. JSE is used largely in government and other formal domains. JC, the language spoken by the majority of African-Jamaican, both in Jamaica and diaspora communities, is restricted to informal interactions and smaller scale undertakings of local scope. However, some Jamaican linguists see such descriptions as an ‘idealised version’ (Bryan 2010). Instead, many scholars have sided with the view that language in Jamaica exists on a Creole continuum extending from the basilectal form, (purest Creole, spoken by most Jamaicans), through the mesolectal form, (usually spoken in urban areas), to the standard language, the acrolectal form (Bryan 2010).

An example of this continuum can be observed in the following Creole expressions: ‘Mi a nyam’ (basilect); ‘Mi eatin’ (mesolect); and ‘I’m eating’ (acrolect). Each of these expressions convey the same idea: ‘I am eating’. However, there is a great variety of ways in which one can convey that idea.

From the perspective of teaching and learning, the complexities of the Creole continuum described above create both theoretical and pedagogical challenges for science instructions. The most common, I would argue, is that of using JSE as the sole language of instruction for JC speakers when their speech is so variable. If science instruction is to be effective, then Jamaican students must be able to draw from the resources of the entire Creole continuum. Within this latter perspective, many scholars have called for greater use of JC across the mainstream education sector (Bryan, 2010).

Science textbooks

The role of science textbooks in the classroom has long been the focus of international study (Groves 2016; Otero, Leon and Graesser 2014). There now seems to be little question of their importance in realising curriculum aims and supporting effective pedagogy (Oates 2014). Indeed, some have even argued that science textbooks represent an infallible source of knowledge, and in some countries, they have become the de facto national curriculum (Lodge

2018). In the Jamaican context, there is considerable dependency on textbooks because of a chronic shortage of specialist science teachers and poorly equipped classrooms (Lodge, 2018). Hence, it is imperative that selected textbooks meet the requirements of its readers; that is, they must provide the detailed knowledge both stated and implied in the curriculum. Moreover, they should be engaging and comprehensible for students, with or without their teachers' supervision.

Yet the outcome of much research has reported that science textbooks recommended by examining bodies are beset with problems. For example, Fang's (2006) study on the language demands of science texts in the USA pointed to the significant comprehension challenges that even students who were proficient readers encountered because of a heavy concentration of technical terms. Similar findings were reported by Soyibo (1996) in his analysis of three secondary school biology textbooks. Soyibo argued that the major difficulties experienced by students in handling the vocabulary features might not only be linked to textbook difficulties but also to a lack of adequate reading skills, preventing students from dealing efficiently with organisational features of the textbooks.

More recently, Groves' (2016) re-evaluation of school science textbooks used in the United States found that they remain problematic for the students. According to Groves, the major difficulties experienced by students were in handling the overload of scientific terminologies in the science textbooks investigated. More worryingly, Groves reported that some of the sampled textbooks exceeded the suggested guidelines for vocabulary instructions in modern foreign language courses, and hence would be extremely difficult for struggling readers and ESL learners.

My approach

Since Soyibo's (1996) study, several Jamaican scholars have examined the language demands of science instructional materials and have reported similar results (see, for example, Lodge 2002). However, these studies relied exclusively on the use of readability formulae and cloze procedures, which highlight the difficulties experienced by readers in understanding text without reference to the cultural and social context of the readers. It is therefore for these reasons that this study considers the extent to which Jamaican students can access the language demands of a popular science textbook. My approach will not only consider the readability elements of science text but will also take into account what Halliday (1978) describes as the ‘context of situation.’ For the purposes of this study, the ‘context of situation’ considers the socio-cultural factors that exist between the text and readers.

Halliday (1978) identified three key areas for language analysis that must be considered: the ‘field’ or institutional setting (which refers to what the participants are engaged in); the ‘tenor’ (which relates to who is taking part and the relationship between participants); and the ‘mode’ (which refers to the channel of communication). These three dimensions of situational context are called registers. Halliday and Hasan (1989) describe the register as a collection of philological and grammatical features that varies from context to context. The notion of register clarifies the distinction between colloquial and scientific language, since scientific discourse has its own terminology and grammar (Halliday and Martin 2003).

In this study, the accessibility of the science textbook to Jamaican science students will be examined from three viewpoints: as a determining factor to the successful completion of a task by the participants (field); as a judgment by the participants, (tenor); and as a constituent of the textbook, (mode). These three elements of the ‘context of situation’ are essential to describe sufficiently the extent to which the textbook is accessibile from a language perspective.

With respect to the students’ performance on the tasks related to the science textbook, a cloze test was adopted, because it has been extensively used as a language proficiency testing tool and has been found to be efficient, reliable, and valid (Gellert and Elbro 2013). Cloze tests do not only measure students’ comprehension of text, but also their aptitude to integrate meaning across successive clauses and sentences (Nellist and Nicholls 1986). Gellert and Elbro (2013, 17) suggest that cloze tests are not just restricted to comprehension but are ‘natural’ tests of inferences, and the inferences are not reduced in reach. Moreover, according to Nellist and Nicholls (1986), cloze tests can also indicate difficulties with vocabulary and have been used to validate scores from readability formulae.

The accessibility of the science text as judged by students and teachers was studied by using individual and group interviews. Interviews have been widely used in educational research and have provided researchers with an incomparably rich source of data. Proponents of interviews as a method of data collection point out that they are highly purposeful tasks which go beyond mere conversations. Studied from the viewpoint, as a constituent of the science text (mode), Fry’s readability formula (1968) was employed. Although there are a number of possible measures that could have been used to assess the difficulty of the text, each of which has advantages and disadvantages, Fry’s readability formula was chosen for this purpose on the basis that it is well established, and over the years has been successfully used to pinpoint "readability levels with reasonable accuracy and uncommon simplicity," (Fry 1968, 513).

Purpose of the study

The main purpose of this study is to determine the extent to which Jamaican secondary school students can access the language demands of science texts. It addresses the question:

- To what extent are the language demands of science texts in Jamaica accessible to their intended audience?

Material and methods

This research which constitutes a sub-study within the context of a larger study examining the accessibility of science instructions in Jamaica, combined readability formulae, cloze tests and interview research methods. A purposive sampling approach was used to select the participants for both the cloze tests and interviews. The cloze test sample consists of 450 Year 7 students drawn from five secondary school types (private, junior high, upgraded, technical and traditional high) in Jamaica. These schools were selected to ensure a diverse range of participants.

Private schools in Jamaica, in the main, are funded in whole or in part by charging for their students' tuition. Hence, they attract students from more socio-economically advantaged families. Furthermore, since they cater primarily for an upper middle class and upper-class student body, students come to these schools already proficient in JSE. They are thus at a greater advantage of accessing curriculum content than the JC speakers in the junior high, technical high and upgraded high schools. The traditional high schools are of the kind that would generally be regarded as 'grammar schools.' Since there are relatively few of them compared with the number of parents wanting to send their children to them, they experience keen competition for the places that they have available. The selection process takes the form of a Grade Six Achievement Test (GSAT) consisting of tests in Language and Mathematics. As Evans (2001) notes, those who do well are guaranteed a place in one of the traditional high schools, and those who do not are relegated to either a junior high, a technical high or an upgraded high school.

In addition, sub-samples of 30 students and 18 teachers from the five school types discussed above were selected for interviews. Interviews were of two types: group interviews with the students and individual interviews with the teachers. For the group interviews, six students who took part in the cloze test were selected from each of the five school types. For the individual teacher interviews, a total of 18 science teachers were selected from each of the five school types. All the schools had an equal number of participants, with the exception of the private school, where only two teachers volunteered to be interviewed.

The interviews were semi-structured and directed by an interview guide (see Appendix 1) that was formulated from the research question. All the interviews lasted for about thirty to forty minutes and were audio-recorded. The data was analysed using the conceptual framework of thematic content analysis outlined by Braun and Clarke (2006). The central function of such an approach is "to allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data" (Thomas 2006, 238). The data was manually coded by first breaking the interview responses down into smaller parts and then putting them back together in clusters that summarised the ideas and issues within the interviews. Examples of the coding framework are presented as Tables 1 and 2.

The cloze test instrument used in this research consisted of nine cloze passages totalling 1,000 words (see Appendix 2 for a sample of the cloze test). Three passages were selected, from the beginning, the middle and towards the end of the textbook. Beginning with the second sentence, every seventh word was deleted and replaced by a blank space. The blanks were all approximately of the same length. Students were credited with marks if their response matched the replacement word or made sense within the context of the passage (Pikulski and Tobin 1982). Data from the cloze test were statistically computed and analysed.

With respect to Fry's readability formula, three random extracts of exactly 100 words were selected from the passages used in the cloze test. The number of sentences in each extract was counted. For a part sentence, the words were counted and expressed as a fraction of the length of the last sentence. The number of syllables in each 100-word extract was also counted. An 'x' was marked on a graph where the average number of sentences and syllables in the extracts intersected. This position provided the US grade level. The US grade level was converted to the reading age (in years) by adding a value of 5. The data in Table 3 presents the various Fry's readability results for the cloze passages used in the investigation.

The textbook analysed in this study was Mitchelmore's (2009) *Investigating Science for Jamaica, Book 1* (Cheltenham: Nelson Thornes). This textbook was selected because a preliminary survey I had conducted indicated that it is one of the most widely used textbooks in the lower forms in Jamaican secondary schools.

Results

Table 3 indicates that the approximate reading age of the text was 14 years. These findings suggest that the textbook is above the reading comprehension level of the intended readers. Fry's readability formula was also used to establish whether or not the vocabulary used in the text is appropriate for its intended readers. The points obtained are above the curve of the graph which implies that the textbook have a higher than average vocabulary, this reduces the text's comprehensibility.

The textbook also contains many technical and non-technical multisyllabic words which can present significant challenges for reading comprehension (Cassels and Johnstone (1985). Take, for example, the authors' description of DNA: "deoxyribonucleic acid, a self-replicating material which is present in nearly all living organisms as the main constituent of chromosomes" (Mitchelmore, 2009 p. 12). The meaning of the sentence is almost totally carried by these multisyllabic words and has Fang (2006) notes students can become overwhelmed with such compacted information, especially for those without sophisticated understanding of clauses structures. Moreover, there are numerous instances of words that have specific meaning in science lexicon and everyday meaning (polysemous words). For example, the word *salt* is used numerous times; in everyday Jamaican context this word denotes 'abjectness' which differs from the scientific meaning, where the hydrogen ion in an acid replaced by a positive ion from a base, carbonate or metal in a neutralisation reaction.

The difficulty level of the textbook could also be attributed to the large number of words per sentence. For example, on page 10 under the heading 'Reproduction in vertebrates,' there were three 15-word sentences, one 18-word sentence and one 19-word sentence. On page 20, under the heading 'Alcohol abuse,' there was one 19-word sentence, one 20-word sentence and one 23-word sentence. Additionally, on page 50, the 100-word sample under the heading *Volcanoes in the Caribbean* contains one 14-word sentence, two 16-word sentences and two 18-word sentences. In addition, the text also contained a large number of nominal expressions (the formation of nouns from verbs or other groups) which according Wellington and Osborne (2001, 66) are problematic features of scientific language. These nominalised words maybe particularly difficult for JC speakers since they lack the grammatical resources to understand the meaning being constructed.

The results of the cloze tests indicate the extent to which the students in this sample could read and understand the science textbook under examination conditions. The results of the distribution of scores are presented in Table 4. The conclusions drawn are based on the reading level categories given by Wellington and Osborne (2001). They suggest that a 'frustration level' occurs when a student's score is between 0% and 39%; this means that even with instructions the textbook will probably be too difficult for students to learn from. 'Instructional level' refers to a situation where a student score is between 40% and 59%; this means that a student experiences a reasonable difficulty level, so that the textbook is only suitable for learning with teacher instructions. 'Independent level' occurs when the student score is between 60% and 100%, indicating that the student can learn science from the text with minimal or no instructions from the teacher.

On the whole, the results as presented in Table 4 indicate that approximately 20% of the total sample of the students read the science textbook at the independent level, about 32% at the instructional level and 47% at the frustration level.

Table 5 presents the results for the school type and the students' reading levels. A Chi square test of independence shows a significant relationship ($\chi_2 = 8.38$, 2 df, $p < 0.05$) between these variables. The percentage of students reading at the independent level at the traditional high (38%) was higher than for the other school types. Equally, the highest number of students reading at the frustration level were in the upgraded high (69%) and the junior high school (75%).

Interviews

Throughout the interviews, the language used to conceptualise scientific knowledge in the science textbook was consistently identified as a major source of difficulty for many Jamaican students. As one participant (Patrice – all names are pseudonyms) noted "I am not very good at reading and writing, so I struggle to make sense of the scientific words. Most times when I asked my teacher for help, she tells me to look up the words in the glossary of my textbook." Similar sentiments were expressed by another student (Mark) who expressed that "I do not like my textbook because I struggle to understand the science words in the passages."

The teachers were also united in the belief that the language of science textbooks posed significant barriers to the learning of science. Indeed, most of the teachers viewed language in science as one of the most challenging demands on their students' science learning. For example, Marie explained that her students were from a low attaining group and she believes that they are exposed too quickly to large numbers of scientific terms, which embody large and complex concepts. Most often these terms are polysyllabic words, which her mainly Creole-speaking students find difficult to grasp or feel confident in using. Marie continued:

> I really doubt if these children can use the textbook on their own; that's why I try to break it [the language] down as simple as possible. I would have to say the language is the greatest concern that I have. Even when I simplify the language [from the textbook] and write it on the board it still requires some explanation. I believe that what is written in the textbook is too difficult for them to make sense of by themselves.

Another teacher (Natalie) also highlighted further problems relating to the spelling and pronunciation of these words:

> Whenever I ask them [students] to read they would hesitate when they get to the technical words and a great amount of time is spent trying to pronounce and spell them. Also, sometimes when you asked them to do homework or prepare ahead before you move on to a particular topic, they would come back the next class and when you are trying to brainstorm or just trying to find out how much they have grasped, you would suddenly realise, that they are struggling to understand specific terms that are unique to science. They would say "Miss, I saw this word and I don't know what it means."

Marie also made unfavourable comments about what she regarded as the impersonal nature of the scientific language used in the textbook. She expressed that:

> The language of science is made difficult because it seldom uses personal expressions or statements. I understand this is important if scientists want to make their work seem more impartial and formal. But, the excessive use of the passive voice can make sentences seem over-complicated. When you see statements like 'the temperature was measured' or 'extra solvent was added to the flask', such statements give no information about the people who made the decision.

In support of Marie's view on the impersonal nature of scientific language, Tammi commented that:

> My students not only struggle to understand scientific terms but also with sentences that are written in the passive voice. These sentences are a little awkward for them because in their English classes this style of writing is not encouraged.

Another important issue highlighted by some of the participants relates to the double challenge that Creole-speaking children face in accessing both JSE and scientific English. One teacher (Jeanne) alluded to this when she asserted that:

> The language of science by its very nature can be very complex and what makes it more difficult for students to understand is that when you think of their first language, the roots and origins of their words differ significantly from the roots and origins of the words that are in the science books. So, for instance, if you were learning Spanish some of the root words for the Spanish words you are learning would be similar to English and so it might be a little clearer if you have mastery of English … mastery of the Jamaican Creole does not mean you understand the etymology of the word that you are looking at in the science book, so when I go to class and I say what is a polymer? Polymers means many parts, so students who have mastered English would probably have met polygamy or some other word that uses the same pretext and it would make sense and they would be able to relate. But when you don't know English, when you have not mastered English and your first and mastered language is Jamaican Creole you can't make those kind of references and then it makes it more difficult for you to understand science jargons.

Further problems identified from the teachers' responses lie not with the novelty of scientific words but with the everyday words that have different meanings in JSE and JC. This poses problems for the learner, as they will need to code-switch from the everyday use of language to the language of science, as one teacher (Carol) explains:

> I can't speak for everyone but a major problem for my students is dealing with words that have specific meanings in science and a different meaning in everyday use. Take for example, the word 'power'. You know power has a different meaning in Jamaica to that used in science and no matter how I try to explain it to the students they always seem to write the Jamaican meaning in the test.

Carol's view was supported by Jasmine from the same school who asserted:

> Most times students use the science vocabulary inappropriately. They often think in layman terms, so when you have words that have meanings in science that are different from their familiar meanings they will always be thinking in layman terms and most of the times it is not correct.

Some students were also critical of the scientific lexis of the textbook. Take, for example, Jane who said, "I think it [the textbook] is very complex. Reason being that some information and explanations are not quite broken down as you would want them. So, most times I struggle to revise for test and do homework from it." Jane further explained that "science have a lot of difficult vocabulary and sometimes when you are reading these words they are difficult to make sense of [pause] so it would be easier to read if the words were broken down simpler." Adding to the thoughts expressed above, Kameka, when asked what she thought about the language of her science textbook, said:

> My textbook [pause] with the aid of my teacher after he explain it in class and I have a level of understanding to know that if I am going to use the textbook it would [laugh] would be easier to understand when you use the notes from the class with the textbook will give us a better understanding. I would have to say though that I struggle to read it without my teacher breaking it down.

Discussion

This study sought to determine the extent to which the language of a popular science textbook is accessible to Jamaican students. Evidences from the readability index suggest that the reading age of the textbook is above the average age of the students for whom it is written. Consequently, it is unlikely to be found readable and comprehensible by the majority of the students without the help of a more knowledgeable other (MKO). Such a situation is problematic given that in Jamaican science classrooms, textbooks are not only the principal source of scientific knowledge but operate as the de facto or 'proxy' curriculum (Lodge 2018). Thus, it is essential that high quality science textbooks are chosen which students can easily read and understand. Scholars such as Soyibo (1996) have suggested that science textbooks used in Jamaican schools should have a reading age at least two years below the reading age of the students, because they are frequently used as unsupported texts, for homework or revision, without direct teacher support. Moreover, advocates of readability formulae argue that readers who are non-standard English speakers, (as is the case for most Jamaican students), should be placed at least a year behind their USA counterparts (Groves 2016).

One consistent finding is that private and traditional high school students outperformed their counterparts in the technical, upgraded and junior high schools. This is not surprising, since access to quality education in Jamaica remains largely determined by societal class, a fact evident not only in the differential resources available to schools but also the background of students entering better-resourced institutions. Thus, the population in the private and traditional schools is composed almost entirely of children from high socio-economic backgrounds, who are likely to be high achievers in the Grade Six Achievement Test. More importantly, these schools are also more likely to have a lower proportion of Creole-speaking children than in the technical, upgraded and junior high schools. Hence, will be more proficient in JSE and have the necessary linguistic resources to assess science textbooks.

One notable area of concern relates to the sentence lengths. In all the cases examined, it is very doubtful that many pupils, when they eventually reached the full stop, could remember what the beginning of the sentence was about, much less extract the essential meaning from it (Graves and Graves 2003). Such an assertion is supported by evidence from scholars such as Scott's (2008) whose study on the assessment of sentence complexity and reading comprehension highlights the deleterious effect that long sentences have on struggling readers. Moreover, considering the low motivation of Jamaican students to study science and to read science textbooks (Soyibo 1996), it is very unlikely that these books would be of interest to potential readers. Although few researchers have been directly concerned about how interest influences the comprehension and recall of expository text, several studies seem to support the hypothesis that motivation plays an important role in reading comprehension (Cuevas, Russell and Irving 2012).

The Cloze results indicate that the majority of the students can only understand the textbook if they are given instructional support. This further highlights the language difficulties posed by science textbooks and emphasises the need for teachers to provide scaffolding strategies to promote students' language development. Curiously, the 47% of students who found the textbook inaccessible corresponds to the data of student achieving acceptable grades in the CSEC integrated science exams. This might provide support for Wellington and Osborne's (2001) argument that understanding the language of science is vital for science learning. Hence, focusing on improving students' understanding of scientific language and making them and teachers aware of its importance in learning science, despite the challenges must be a major goal of policymakers.

With respect to the interviews, the findings reveal that although teachers perceived the language use to construct scientific knowledge as a major source of difficulty for science learners, they demonstrated a high level of agency in making science textbooks accessible to the students. There seem to be a recognition by the teachers that they were well placed to understand the linguistic struggles the students experience when acquiring scientific knowledge. Thus, they routinely translated textbook content into JC and encouraged translanguaging as a natural part of scientific discourse. Thus, challenging the linguistic hegemony in their classroom. Cummins (1994) see this as creating "conditions for interaction which expand students' possibilities for identity formation and critical inquiry" (p. 47). These observations are part of the growing recognition by the teachers that their classroom is a bilingual and bicultural environment and, thus, by linking modes of discourse between JSE and JC, "students' voices can be expressed, shared and amplified within the interactional process" (Cummins, 1994, p. 47).

Conclusion

The preceding discussion has thrown into sharp relief the meretricious obstacle that scientific language presents to Jamaican science learners. What is also evident is that the problems of scientific language in science textbooks are not just unique to these learners but are consistent with the findings of many international studies discussed earlier. Undoubtably, students must learn this language, since as Wellington and Osbourne (2001, 6) argue "learning to use the language of science is fundamental to learning science". However, teachers need to implement greater linguistically informed strategies in order to better facilitate student's understanding of the language being used. To support this, a Vygotskyan scaffolding intervention framework which include using a smaller number of key vocabulary words, both content-specific and general academic forms and using synonyms or paraphrasing difficult language could be used. Such interventions, I would argue can support students' comprehension without diminishing the challenge of science content.

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Appendix 1

Students Interview Guide

1. What do you think makes a great textbook?
2. What do you think about your science textbook?
3. What do are your views on the language of science textbooks? Are they written in a way that they can be easily understood?
4. How do you think the language in science textbooks can be improved?
5. Are you comfortable speaking both Jamaican Standard English and Jamaican Creole?
6. In what context do you speak both languages?
7. Are there anything good about your textbook being written in Jamaican Standard English?
8. So, what if your science textbook was written in Jamaican Creole? How would you feel about that?
9. Do you think Jamaican Creole has a place in the science classroom?
10. How often do you use your science textbook?

Teachers' Interview Guide

Teacher's role and responsibility

1. How would you describe your role as a Science teacher?

2. What do you consider to be the main purpose of teaching science?

- Why is it important for Jamaicans to learn science?

3. How would you describe the students' language usage in the classroom?

- Do they use JC only? JSE only? Or a mixture of JC and JSE?

Pedagogical awareness

4. How and when do you use JSE and JC in your teaching? Tell me about any challenges that creates.

5. Would you say the students are equally good at JC and JSE by grade 9 or are they still in a transitional state? How does this affect your teaching?

6. Do you think spoken English proficiency is important for success in science?

7. How often do you use science textbooks in your teaching?
8. In what situations do you normally use them? Tell me more about that.
9. How do you introduce a textbook to your class when you use it?
10. What are your views on the language of science textbooks? Are they written in a way that the students can access them easily? Tell me more about that.

Language awareness

11. Are you comfortable speaking both SJE and JC?
12. In what context would you use Creole?
13. Do you consider Jamaica to be an English-speaking country? Tell me more about that.
14. Tell me about how you support students' language awareness in your class.

- In separating SJE from JC?
- Encouraging them to express scientific ideas in JC?

15. Are you familiar with the Ministry of Education curriculum guide and language policy? If 'yes', how do you implement the policy?
16. How serious do you think policy makers take issues of language problems in communicating scientific understanding?
17. What are your views on using JC to teach science? Tell me some more about that? Is there anything else you want to say?

Appendix 2: Sample of cloze test extract.

Name: ……………………………………………..**Date:** ……………………………….

School ……………………………………………   **Gender**: …………………………..

Instructions:

In the following three passages some words have been left out. First read over the whole passage and try to understand what it is about. Then try to fill in the blanks with words that would complete each sentence. It takes only one word to fill in each blank. You may stop answering questions at any time during the test.

Unit 4

Human Reproduction and Responsible Living

Alcohol Abuse

In the study carried out with post-primary …………………………, alcohol was more than twice as ………………………… to be abused as other drugs. ………………………… greatest number of children were involved …………………………grade 7 (22.9% of girls and 37.5% of boys) . …………………………there was a reduction, year on …………………………, up to grades 12 and 13 where they were ………………………… less than 1%. At all grade levels, …………………………of alcohol was higher among boys ………………………… girls.

Effect of drinking

A little alcohol taken occasionally ………………………… food can help a person to relax ………………………… . But too much alcohol can affect ………………………… brain so actions cannot ………………………… controlled properly. After more alcohol, the ………………………… may become slurred and walking is ………………………… Additionally alcohol can cause the person ………………………… lose consciousness.

A person who regularly ………………………… too much can damage their liver, ……………………… is an extremely important organ for ………………………… the whole body running properly. . ………………………… liver may be poisoned and may ………………………… cancer. This can cause death.

Pregnant ………………………… are advised not to drink any …………………………, especially in the first three months ………………………… pregnancy, as this could harm their ………………………… baby. Parents should also not give alcohol ………………………… babies to help them sleep as ………………………… can cause confusion and bad habits ………………………… on.

As the person who is ………………………… gets energy from the alcohol, this …………………………mean that they are not getting ………………………… proper balanced diet.

Yet they put …………………………weight around the abdomen: this is …………………………a 'beer belly'.

Excessive drinking also causes …………………………in family life and in the ………………………… When people are drunk they lose …………………………, can become violent and hurt other …………………………

Alcohol relaxes a person so they ………………………… be more likely to be sexually …………………………, or to take drugs that they ………………………… otherwise refuse.

Alcohol makes a person ………………………… they can do things they really …………………………, such as drive carefully. Drunk drivers ………………………… too many risks. Many road accidents ………………………… caused by people who are driving ………………………… drunk. They may even cause accidents ………………………… which they or others are injured ………………………… killed.

Table 1 Example of the initial coding framework

Interview transcript	Initial coding framework
Wilton: OK, so what do you think makes a great textbook? Any one wants to talk about that … What makes a great textbook?	
Tammi: I think a good textbook is one in which the language is clear and easy to understand … Umm… (pause) It should be well written and have some really good pictures to explain come of the scientific ideas. A good textbook should have interesting diagrams and pictures. I think I learn a lot from diagrams and pictures. Oh... and sir, it must have enough information so we can study and pass our exam.	Language Visual representation Subject narrative
Kameka: Sir, a good textbook is one that doesn't have a lot of difficult scientific terms; it must be easy to read and understand. It is one that doesn't jump between ideas but link them in a logical way.	Scientific lexis Text organisation

Table 7.2 Final coding framework after reduction of the categories in the initial coding framework

Final coding framework	Initial coding framework
Language and communication	• Scientific language • Scientific lexis • Visual representation • Text organisation • Subject narrative
Scientific discourse	• Science talk • Science text • Factors affecting scientific discourse • Role of the teacher in scientific discourse
Language ideologies	• Attitudes towards Jamaican Creole • Hegemony of Jamaican Standard English

Table 3 Average number of sentences, average number of syllables and reading age for the three extracts

Extracts	Sentences per 100 words	Syllables per 100 words
100 – word sample, page 10	7.6	150.3
100 – word sample, page 20	8.6	160.5
100 – word sample, page 50	9.1	162.3
Average	8.4	157.7

Table 4 Percentage of students who were categorised as independent, instructional and frustration readers based on their scores in the Cloze test

		Frequency	Percent
Valid	Frustration	70	47.0
	Instructional	48	32.2
	Independent	31	20.8
	Total	**149**	**100.0**

Table 5 The reading comprehension of students based on school types

			Reading Comprehension			
			Frustration	**Instructional**	**Independent**	**Total**
School Type	**Private**	Count	1	14	6	**21**
		% within School Type	5%	67%	29%	**100%**
	Traditional High	Count	0	15	9	**24**
		% within School Type	0%	63%	38%	**100%**
	Technical High	Count	20	8	8	**36**
		% within School Type	56%	22%	22%	**100%**
	Upgraded High	Count	22	6	4	**32**
		% within School Type	69%	19%	12.5%	**100%**
	Junior High	Count	27	5	4	**36**
		% within School Type	75%	14%	11%	**100%**