Readability Analyses of Integrated Science Textbooks for Junior High Schools in Ghana

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Abstract

This study investigated the readability levels of some integrated science textbooks approved for use in junior high schools (JHS) in Ghana. To assess the readability levels of the approved integrated science textbooks in order to ascertain their difficulty or ease, the researchers used the Flesch Readability Ease and Flesch-Kincaid Readability Formulas Cloze Test to determine the comprehension levels for a sample of students. A sample of 135 pupils, drawn from rural, peri-urban and urban JHS years 1 through 3 in the Ashanti region participated in the study. The outcome of the assessments revealed that the selected textbooks had a problematic level of comprehension for many of their intended readership except those who had additional resources for assistance. The study also revealed that these approved books employed long sentences and multi-syllabic words to deliver lessons and instructions, making them difficult for JHS pupils to understand.

Keywords integrated science, textbook, readability, Flesch readability ease, Flesch-Kincaid, cloze test

Introduction

The importance of science education for the development of every economy cannot be over-emphasised. Its relevance is captured in the words of Nehru who pointed out that

> It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, or a rich country inhabited by starving people…. Who indeed could afford to ignore science today? Every turn we have to seek its aid … the future belongs to science and those who make friends with science (Vinod & Deshpande,2013, p. 507).

Gyasi (2013, p. 1) also emphasises that science "plays a crucial and pivotal role in the alchemy of scientific research and technological innovations." These have become the catalysts for the development of every nation." Without providing the appropriate textbooks at various science education levels, these scientific and technological innovations are not achievable. This can be comparable to "democracy without the appropriate constitution or farming without functional farm implements" (Gyasi, 2013, p.9). Textbooks are essential tools for education (Izgi & Seker, 2012; Devetak &Vogrinc, 2013). These educational materials should have the cognitive and perceptive capabilities appropriate for users' age and knowledge level (Izgi & Seker, 2012), making them productive and useful for users' independent study.

Central to the appropriateness of textbooks for their users, irrespective of education level, is readability (Scot, 2011). Thus, the text should be reader-friendly and should neither be too difficult nor too easy to read. It should be easy to comprehend and difficult enough to

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contribute to students' academic development (Scot, 2011). Essentially, writers and publishers have been encouraged to pay attention to the language component of science textbooks, as it is a significant factor in the comprehensibility of any written material (Willington & Orsbone, 2001; Gyasi, 2013).

Gyasi (2013, p. 9) cautions that "language use is a major barrier to most students in learning science", making it difficult for students whose mother tongue is not the language used for instruction to understand what they read or are taught. This situation is what Yong (2010) describes as making the learning of science difficult because one has to master both the language and content of science and language of instruction simultaneously (Rollnick, 1999). Such a situation is the fate of Ghanaian school pupils; they must understand English, which is their second language but used as the official communication language, the language for instruction, and science. Some Studies (Curtis & Millar, 1988; Bryce, 2013) have alluded that native English-speaking pupils struggle with understanding science textbook language. This evidence suggests that it could be a challenge for Ghanaian pupils since they begin to learn English as a second language officially from class 4, much less grasp the technicalities that science profess.

The situation becomes even more complicated when words are not translatable between English and their first language (Asabere-Ameyaw & Ayelsoma, 2012). The difficulty with language in textbooks is complicated by "the confusion between the language used at home and language of instruction" (Ayodele, 2013). It is not surprising that the West Africa Examination Council (WAEC) report on the performance of science subjects by junior high school pupils indicated a below-average performance, with the chief examiner stressing the low use of the English language in answering questions (WAEC, 2015).

Textbooks cover about 75 to 90 per cent of classroom instructions (Stein, Stuen, Carnine & Long, 2001), and so they need to be accurate and appropriately target the levels of their audience (Hubisz, 2003). They must provide access to informational text that the targeted audience can read and understand (Bryce, 2013) since they are the foundational tools for acquiring formal knowledge and skills for human and national development (Essuman & Osei-Poku, 2015). The progressive decline in junior high school students' performances in the Basic Education Certificate Examinations has been a source of worry for educationists, teachers, and parents in Ghana. The lower performance levels are severe in the science subjects (Ghana News Agency, 2010; Kweitsu, 2014).

Since Ghana's independence, successive governments have made efforts to improve infrastructure and increase textbooks and other teaching and learning resources in schools. Despite these efforts, studies show myriad challenges; the lack of conducive learning environment, non-availability of textbooks, lack of teacher motivation still hamper the effective delivery of primary education in Ghana (Wienstein, 2011). The majority of studies targeted at providing the solution to these poor performances of students have always been around the provision of infrastructure, textbook and issues of teacher motivation (Glewwe & Kremer, 2006; Opoku-Amankwa, 2010), with little or no attention given to the content of the materials used by pupils in terms of their appropriateness for their level of readership.

Upon this premise, the Government of Ghana's Ministry of Education (MoE), through the National Council for Curriculum and Assessment (NaCCA), has taken the sole responsibility to ensure that textbooks are

developed and appropriately evaluated under the right stipulated standards established by policymakers. Therefore, this study sought to determine whether or not the content of some integrated science textbooks, recently approved by the government, meets pupils' grade levels as a means of enhancing science education in Ghana. Specifically, the study was guided by the following research questions:

1. How do readability formulas rate the level of difficulty for the approved integrated science textbooks used for the study?
2. What is the level of performance of pupils on the comprehension of the textbooks selected?

Readability and Textbooks

Textbooks approved for use in schools, especially in developing countries such as Ghana, faces criticism for not going through rigorous evaluation processes where critical issues such as language difficulty, line length, layout and presentation are thoroughly examined (Essuman& Osei-Poku, 2015). Language difficulty presents a challenge to the two primary users of textbooks: the teacher and the pupil. The teacher would find it difficult to explain concepts, especially in the Science subjects as presented in the texts to the pupils, and the pupils will have difficulty reading and understanding these materials when instructed to do so or while studying on their own (Asabere-Ameyaw & Ayelsoma, 2012).

One's ability to comprehend a given passage depends significantly on its readability, the straightforwardness of the language used in the text, the reader's knowledge of the vocabulary used and the reader's ability to make meaning of the text (Wissing, Blignaut & Van den Berg, 2016). Understanding the written words presents a difficult challenge for many primary school pupils (Uchennah, 2002). Most of these core subject textbooks, such as science, are in the English language, which in many cases are pupils' second language (Ayodele, 2013 and Gyasi, 2013). Bryce (2013) thus opined that this makes science textbooks challenging to read.

There are two contributors to easy reading; the reader and the text (DuBay, 2007). Readability is an attribute of text, while comprehensibility is an attribute of the reader (Jones, 1997; Wissing et al., 2016). Factors such as reading skills, interest and motivation (DuBay, 2004) contribute to reading ease. On the side of comprehension— extracting and constructing meaning from the written language (Snow, 2002), the text readability hinges on content, style, design and organisation (DuBay, 2007).

In the developed worlds, teachers and authorities rely on various instruments such as the Readability test formulas to select the most appropriate textbooks. According to Edgar Dale and Jeanne Chall (1949) (see Dubay, 2004, p.76), Readability is "the sum total (including all the interactions) of all those elements within a given piece of printed material that affect the success a group of readers have with it. The success is the extent to which they understand it, read it at an optimal speed, and find it interesting." Readability formulas are tools for measuring certain features of a text-based on mathematical calculations.

These formulas are objective and based on measurable features of writing (Venable, 2003) and "have been well researched as being indicative of whether a text will be understood by its intended readership" (Wissing et al., 2016, p. 159). There are over 200 such instruments in use (Mesmer, 2008) but the most used include Simple Measure of Gobbledygook (SMOG) index, Cloze test, Flesch Reading Ease, Fry's Readability Graph, Flesch-Kincaid Grade Level test (DuBay, 2004). These formulas usually measure the complexity of sentences and words. The

average words per sentence measure the complexity, while the complexity of words is measured in slightly different ways (Karmakar & Zhu, 2010).

Flesch Kincaid Reading Ease and Flesch-Kincaid Grade Level tests use the average number of syllables per word, while the Coleman-Liau Index and the Automated Readability Index uses the average number of characters per word. Gunning Fog Score and SMOG index use the percentage of polysyllables (complex words, or words with more than three syllables). In contrast, the Dale-Chall Readability Formula uses the ratio of difficult words not on a 3,000-familiar word list (Karmakar & Zhu, 2010 p. 292).

These readability formulas have advanced through numerous changes and improvements since their inception in the 1920s (DuBay, 2007), and with the development of new procedures (Guven, 2014), all aimed at getting an appropriate balance between supports and challenges (Tabatabaei & Bagheri, 2013).

Some studies (Ajideh & Mozaffarzadeh, 2012; Janan & Wray, 2012) have cautioned the use of readability formulas as being too simplistic in their calculations since they do not take into account certain factors such as reader motivation, interest, competitiveness, value and reading purpose as summed up by Bryce's caution (2013, p. 105);

Readability formulas do not consider many factors that affect the difficulty of a given text for particular readers. Characteristics such as reader background and familiarity with the topic, text structure and organisation, coherence, or audience appropriateness can influence how challenged readers are by a given text.

Despite these criticisms, the use of these formulas is growing because of the degree of consistency that each formula offers in its predictions of the difficulty of a range of texts and the closeness with which the formulae are correlated with reading comprehension test results" Stajner, Evans, Oransan and Mitkov (2012, p. 4), providing a single, summary average score without requiring to know the characteristics of the eventual reader of the text (Wissinget al., 2016) and offering unbiased grade levels that educators and teachers can have confidence in predicting the level of reading difficulty in matching reader to text (Chall, 1981).

As a result, these formulas are useful tools for measuring the difficulty of reading materials (Chall 1981) by providing means of differentiating between easier and harder text (Janan & Wray, 2012). Ayodele (2013) posits these tools "No matter the choice of the formula or graph if the readability level of the textbook exceeds the selected grade level, such a book is often not considered an appropriate choice for the students" (p. 110). Children with successful and exciting experiences with books are more likely to be motivated to continue, while the reverse will experience a decrease in motivation, increased exasperation, and depleted self-esteem (Mesmer, 2008).

The Flesch Reading Ease (FRE), the Flesch-Kincaid Grade level Formulas and the Cloze Test were tools used in the study. These tools are the most widely used in this area of study (Bormuth, 1969; Tabatabaei & Bagheri, 2013) and the most reliable and tested formulas of readability (Bargate, 2012).

The Flesch-Kincaid Grade Level and Flesch Reading Ease formulas are variations of the original Flesch Readability formula published in 1943 (Mesmer, 2008). The Flesch Reading Ease (FRE) is used to determine a given text's reading difficulty without assigning any grade level. This formula scores the readability of a given sample with the range 0–100. A score of 0 means the text is challenging to read, while a 100 score indicates easily readable content.

According to Wissinget al. (2016, p. 159), "text with a readability score of 90–100 indicates that a reader, who has completed Grade 4, should be able to correctly answer 75% of comprehension questions set over the text." The inability of FRE to give a definite grade level resulted in its modification by Kincaid and his team.

In 1976, J.P. Kincaid and his team modified the Flesch Reading Ease to produce a grade-level score, that is Flesch-Kincaid Grade Level formula. A score obtained from the formula indicates the grade-school level. For instance, 8.3 means an 8th grader would be able to read that content.

The Microsoft Word application has incorporated the Flesch Reading Ease and Flesh-Kincaid grade level formulas for more straightforward calculation of readability levels for users of such computer application due to their acceptability in the area of readability studies (Wissinget al., 2016).

Taylor in 1953 introduced Cloze Procedure and was revised by Bormuth in 1969 as a tool for measuring reading comprehension, citing several difficulties with the readability formulas of Flesch and Dale- Chall on the basis that words are not the best measure of difficulty but how they relate with one another (Fatoba, 2014). This formula's validity lies with its consideration for reader qualities, proving to measure reading comprehension objectively, reliably and validly (Wissing et al. 2016).

In a Cloze Test, several passages with equal length are used. Cloze Test is a deletion test (Mesmer, 2008) based on the theory that readers are better able to fill in the missing words as their reading skills improve (Ayodele, 2013; Helfeldt, Henk, & Fotos, 1986). The test is constructed by deleting random words, significant words or every nth word from the passage and replacing the deletion with space of equal length. One's ability to correctly fill in the missing vocabulary indicates the reader's understanding of the material (Taylor, 1957). This feat becomes achievable through critical thinking as two mental competencies – syntagmatic and paradigmatic are activated during the Cloze test (Kılıçkaya, 2018).

The accuracy rate is dependent on readers identifying the exact words deleted from the passage. The lower the score, the more difficult the text is and vice versa. An interpretation of a Cloze test score is as follows:

- between 0% and 39% suggests Frustration Level– that the language was difficult for the readers to cope with,
- between 40% and 59% indicates Instructional level – readers need some assistance in their comprehension, and
- 60% to 100% indicates an Independent level – where readers can cope with the language (Wellington & Osborn, 2001).

Methodology

The study is a content analysis using the Flesch Readability Ease, the Flesch-Kincaid Grade level Formulas and Cloze Test to measure the level of comprehension and the suitability of the study material for the grade level of the users. Questionnaires were administered to pupils and teachers to elicit additional information regarding the pros and cons of using these materials.

The Flesch Readability Ease and Flesch-Kincaid formulas were used to determine the suitability of the passages selected for the readership and to determine their grade levels. These formulae are used to determine the vocabulary load of a given text and assign the appropriate level of readership for it. The mathematical formulas are as follows:

- Flesch Reading Ease (FRE) formula: $FRE = 206.835 – (1.015 \times ASL) – (84.6 \times ASW)$; and

- Flesch-Kincaid Grade Level (FKGL) formula: FKGL = (0.39 × ASL) + (11.8 × ASW) – 15.59.

ASL is the average sentence length (the number of words divided by the number of sentences). ASW is the average number of syllables per word (the number of syllables divided by the number of words). Table 1 shows the Flesch Reading Ease Score interpretations based on reading difficulty levels assuming the reader's mother tongue is the English language suggested by Wyatt and Schnelbech (2008).

Table 1 Interpretation of Flesch Reading Ease Score

Reading Ease Score	Description	Reading Grade
0-29	Very difficult	Postgraduate grade
30-49	Difficult	College grade
50-59	Fairly difficult	10^{th} – 12^{th}-grade high school
60-69	Standard	Standard 8^{th} – 9^{th} grade
70-79	Fairly easy	7^{th} grade
80-89	Easy	5^{th} – 6^{th} grade
90-100	Very easy	4^{th} - 5^{th} grade

Source: (Wyatt and Schnelbech, 2008)

Table 2 Cloze test interpretation

Cloze scores	Reading level	Description
60-100%	Independent	Material is too easy
40-59%	Instructional	Material is appropriate
0-39%	Frustration	Material is too difficult

Source: (Wellington and Osborn, 2001)

The comprehension levels of pupils were measured using the Cloze Test. In the Cloze Tests, every fifth-word was deleted from the selected sample passages and were administered to the pupils to measure their reading comprehension levels. The study took place during regular class hours, with permission from the various headteachers and class teachers. The study material – selected passages were read and explained to the pupils for 30 minutes, after which they did self-reading for 15 minutes. Afterwards, respondents handed over their study materials, and the Cloze Test administered lasting 30 minutes.

In scoring the passages, the substituted or similar words were counted as correct (disregarding spelling errors) and then divided by the total number of spaces provided. It was then multiplied by 100 to give the percentile Cloze Score of the students. Wellington and Osborne (2001) interpretation was adopted in the study, as shown in Table 2.

A sample population of 135 Junior High School pupils drawn from year 1 to 3 was selected from three schools, with 45 pupils drawn from each school. Fifteen chosen pupils from each class have an average population of about 45 (JHS 1, 2 and 3), ranging between 12 to 17. Respondents were randomly selected by lot casting with help from their class teachers. The study took place in the Kumasi Metropolis of the Ashanti Region of Ghana.

The New Integrated Science for Junior High Schools (3^{rd} edition) textbook published in 2012 was purposefully selected since that was the most commonly used Government

Approved Integrated Science textbook within the study area. A 3 x 3 Passages with a minimum of 100 words were randomly selected from the front, middle and last sections of each of the Pupil's Books 1 to 3. The specific page numbers of the passages chosen were as follows: Book 1 (pages 10, 86, 139), Book 2 (pages 13, 50, 67) and Book 3 (pages 9, 120, 150). The selected passages' average score was used to determine the readability level and the grade level each book is meant. A questionnaire was administered to pupils to determine their understanding of the passages read, whether they received any help at home concerning their learning or were given extra tuition in school or home using their integrated science textbook and other materials. The questionnaire was administered based on their study levels (i.e. form 1, 2 or 3). Tutors who handled these subjects in the study areas were given questionnaires soliciting their views on the study's textbooks. Data were analysed based on their study levels.

Findings

How do readability formulas rate the level of difficulty for the approved integrated science textbooks used for the study?

Recorded scores for the readability of the Integrated Science for Junior High Schools books 1-3 passages showing the grade levels and reading ease is shown in Table 3 with its interpretation based on Table 1.

Table 3 Results for Flesch Reading Ease and Flesch-Kincaid grade level of JHS Integrated Science textbooks 1-3

	Total words	Total sentences	Total syllables	Average sentence length	Average Syllables per word	Reading Ease Score	Grade level
JHS 1							
Passage 1	100	6	174	16.66667	1.7	42.71433	11
Passage 2	106	7	174	15.14286	1.6	52.5933	10
Passage 3	101	7	199	14.42857	2.0	25.50287	13
Average score of 3 passages	102	6.7	182.3	15.4	1.8	40.3	11.5
JHS 2							
Passage 1	102	7	177	14.57143	1.7	45.23912	11
Passage 2	104	8	162	13	1.6	61.85923	8
Passage 3	103	10	203	10.3	2.0	29.64458	12
Average score of 3 passages	103	8.3	180.7	12.6	1.8	45.6	10.0
JHS 3							
Passage 1	111	6	193	18.5	1.7	40.9602	12
Passage 2	104	5	173	20.8	1.7	44.99415	12
Passage 3	103	5	186	20.6	1.8	33.15318	14
Average score of 3 passages	106	5.3	184.0	20.0	1.7	39.7	12.7

What is the level of performance of pupils on the comprehension of the textbooks?

According to their performance in the Cloze test, the Correspondents' computational results, with an interpretation based on Table 2, are shown in Table 4.

Table 4 Cloze test for the three schools

Textbook/ Class	Cloze score	Total number of respondents	Percentages (%)	Cloze reading score
Book 1 / JHS 1	0-39%	14	31	Frustration
	40-59%	21	47	Instructional
	60-100%	10	22	Independent
	Total	45		Total
Book 2 /JHS 2	0-39%	11	24	Frustration
	40-59%	21	47	Instructional
	60-100%	13	29	Independent
	Total	45		
Book 3 / JHS 3	0-39%	3	7	Frustration
	40-59%	12	27	Instructional
	60-100%	30	67	Independent
	Total	45		

Some of the schools' environmental conditions are not conducive for effective teaching and learning. Some pupils also seem to be far ahead (Intelligent quotient) of their peers during interactions before taking the cloze test.

Discussion

Using the Flesch Reading Ease formula, the study showed that these integrated science textbooks' readability levels are challenging for their respective grade levels. The average readability scores recorded for the readers were high, as shown in Table 3. Based on Wyatt and Schnelbech (2008) interpretation, the appropriate grade levels for the selected books should be for students above the tenth grade, that is, Senior High School levels in Ghana based on the assumption that pupils in Ghanaian schools are a native speaker of the language of instruction upon enrolment. Contrary to this, pupils' use of the English language (L2) starts at class four based on Ghana's official educational policy (Owu-Ewie, 2013). This show that the text is way above the grade level of such pupils, coupled with the language of science itself.

Again, the Cloze Test scores indicated that Pupil's Books 1 and 2 are way above the pupils' comprehension levels (Table 4). Only a minority of pupils can use the books independently, with the majority (60%) reading at the instructional or frustration levels suggestive that pupils need assistance before using these materials. Although Pupil's Book 3 recorded a high readability ease score, most pupils have a comprehension rate of 60-100%, which suggests the material is written to match the comprehension level of its intended grade which seems to go contrary to literature (Owu-Ewie, 2013). Hower analysis of the questionnaire shows that most pupils in JHS 1 and JHS 2 did not attend any extra classes or did not have any additional tutorial support at home or after school. On the other hand, since the third-year pupils were preparing for their final examination (Basic Education Certificate Examination) for progression to Senior High School during the study, many of these pupils were given extra tuition in school and some at home. This

phenomenon could account for the JHS 3 pupils' better performance even though the text at that level was graded high. It is wealth noting this study was conducted in an urban environment where the socio-economic backgrounds of guardians are averagely better, with guardians capable of affording extra tuition to augment what wards learn in school. However, without the afford mentioned helps, pupils could be facing challenges that would not motivate them to take up science or even pass their basic examination in science to have the chance to read science-related courses in senior high schools.

Further analysis of pupils' questionnaires shows that pupils will like the government-approved textbooks reviewed to make the book more understandable and usable. Some of these suggestive revisions included; words in the texts should be more straightforward for reading and understanding, complex and technical terms used in the passages should be explained by teachers or explanations provided on that page, and a simple explanation be given in the glossary, illustration provided must be well labelled to provide a better understanding of the written text. Pupils should have the opportunity to take the textbooks home on weekends.

On a different and equally important plane, tutors in the respective schools who handled integrated science indicated that the textbooks' writing style is intricate for the pupils and complained about the inadequacies regarding content coverage as required by the syllabus; hence, they often consult other Science textbooks.

During the study, latent factors were observed to hinder the pupils' reading comprehension levels. The environment within which teaching and learning took place was one key factor. The intelligent quotients (IQs) of some of the pupils were comparatively higher, making comprehension unbalanced as some pupils understood the passages better than others based on the Cloze test result.

Additionally, the complexities with vocabulary length and structure inherent in the science textbooks contributed to their reading difficulty resulting in their lower and sometimes no comprehensibility. However, this might not always be the situation. As in some cases, the length of the sentences and number of syllables per word does not necessarily contribute to the complexity but rather the topic under study and the pupils' familiarity. A word's unfamiliarity can also contribute to its difficulty. Sentence length and syllabic count can only support the readability process but cannot, on their own, conclude the readability of a text.

A similar study by Gyasi (2013) regarding integrated science textbook used in senior high school showed a similar trend where the material was challenging for the levels. Therefore, it is not surprising that only 7% of about 500,000 students studying in Ghana's Universities at the undergraduate level are pursuing science-related courses (Ibrahim, 2018). Suppose the majority of students are having challenges passing the essential requirement of science at the junior ranks, then the situation needs critical consideration as their lack of motivation to take up science in the higher levels would in the long-term hamper Ghana's scientific and technological innovations for national development.

Conclusion and Recommendation

From the findings and data analysed, the conclusion is that the JHS 1 to JHS 3 Government Approved Integrated Science textbooks studied were written at levels that are too challenging for the intended pupils to read and comprehend independently, and even sometimes with help. With over 73% of the students selected from three different Junior High Schools at various study levels of form 1-3 reading at the Frustration Level, it is obvious the New Integrated Science for Junior

High Schools, Pupil's Books 1-3 are challenging for pupils. These are textbooks approved by the authoritative voice on education purported to have undergone rigorous evaluation and selection. What then would be the case with materials not authorised but are still in use in the classrooms? This discussion is beyond the scope of this study and would need further probing to come out with the relevant research indications that would help correct the system.

It is recommended, among other things, that text materials for these pupils should match their reading levels for easy comprehension. As such, long sentences and multi-syllabic words are reduced into smaller components for easy understanding. All stakeholders, including policymakers, the Department of Publishing Studies of the Kwame Nkrumah University of Science and Technology, publishers, teachers, and parents, be involved in the developing and evaluating processes.

This study looked at the textbooks semantic and sentence difficulties but not the relationship between text and images used, which could be a catalyst for understanding. Further studies are needed to assess whether the illustrations and graphics used in these materials could help with the comprehension levels.

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