G-CARD
GITOYA CENTRE FOR ACADEMIC RESEARCH AND DISSEMINATION

East African Journal of Education and Social Sciences
EAJESS September –October 2023, Vol. 4, No. 5, pp. 72-82.
ISSN: 2714-2132 (Online), 2714-2183 (Print). Published by G-Card
DOI: https://doi.org/10.46606/eajess2023v04i05.0321.

Free and Suitable? Readability Analysis of Ghana's Senior High School Core Science Textbooks

Faustina Nankuri
ORCiD: https://orcid.org/0000-0003-0897-534X
Department of Languages, Nurat Jahan Ahmadiyya College of Education, Ghana
Email: tinanankuri@gmail.com

***Joseph Sarpong Dwumoh**
ORCiD: https://orcid.org/0000-0002-1315-2690
Department of Agricultural Economics and Extension, University of Cape Coast, Ghana
Email: nanakwasisarpong@gmail.com

William Kodom Gyasi, PhD
ORCiD: https://orcid.org/0000-0003-2013-5247
Department of Communication Studies, University of Cape Coast, Ghana.
Email: william.gyasi@ucc.edu.gh

Corresponding Author: nanakwasisarpong@gmail.com

Abstract: This descriptive study assessed the linguistic complexity of the three Ghana Senior High School Integrated Science textbooks, using readability index analyses. Simple random sampling was used to select five units from each textbook for testing. Criterion-based sampling was used to select, from each sampled unit, a block of texts of no less than 300 words for analyses. Readability score for each sampled text was generated by feeding the sample into the online readability calculator. Simple descriptive statistics were run in order to organize and summarize characteristics of the sampled text. Then, Analysis of Variance procedures, both parametric and non-parametric, were run to test the statistical significance of differences, if any, among the readability scores of the textbooks. The study established that while science textbooks for SHS 2 and 3 and were suitable for their intended audiences, the readability of Book 1 placed it at the level of university students, and therefore, too difficult for its intended audience. There were no statistically significant differences in the mean readability levels of the textbooks at 0.05 alpha level, suggesting that there is no progression in reading and comprehension difficulty among the three textbooks. A recommendation is made for further evaluation of all the textbooks and particularly of Book 1 for possible revision, which may help students to achieve the intended meaningful learning.

Keywords: Readability; textbooks; science education; senior high school; Free SHS.

How to Cite: Nankuri, F., Dwumoh, J. S., and Gyasi, W. K. (2023). Free and Suitable? Readability Analysis of Ghana's Senior High School Core Science Textbooks. East African Journal of Education and Social Sciences 4(5), 72-82. Doi: https://doi.org/10.46606/eajess2023v04i05.0321.

Introduction

The development and application of science and technology form a core part of any country's developmental efforts (Azure, 2015; Nunoo et al., 2022). High quality science education is vital to the preparation of individuals to confidently pursue careers in scientific fields. Furthermore, high quality science education is necessary in preparing individuals to successfully function in the modern global economy, to face new global challenges and to make sound decisions driven by the scientific understanding (Pelekh, 2020).

As media for knowledge transfer, textbooks are crucial to the politics and methods of teaching and for students' success in any field of study, including science (Fisher, 2018; Fuchs & Bock, 2018; Robinson et al., 2014; Tárraga-Mínguez et al., 2021). Providing students with adequate numbers of textbooks is necessary but not enough to foster learning. Curriculum material of sound design can bring about better student learning outcomes (Robinson et al., 2014). As Chambliss and Calfee (1989, p. 307) stated, "theory and practice both suggest that well-designed science textbooks can enhance student understanding" (p. 307). Therefore, the ease with which learners may read textbooks is of critical concern (Chambliss, 2002). The ease or difficulty with which students can read and comprehend written material is broadly referred to as *readability* (Yi et al., 2019).

In the learning of Science, language use is an acknowledged hurdle for most students (Wellington & Osborne, 2001). Students in English as a Second Language (ESL) situation engage in two concurrent cognitive enterprises when learning science. The first is learning a new language (i.e. English) and the second is learning science (i.e. language of science) (Lemke, 1998). The indication is that students do not only learn Science through English but also have to deal with mastering the Science content while learning language at the same time. This situation, by itself, presents a two-fold challenge. Further reading difficulties can occur when there is a gap between a reader's language proficiency and the linguistic complexity of the text they read. That is, when a text is too difficult, it affects the students' ability to understand it. On the other hand, when the authors simplify the text in its linguistic form while retaining all the content, it significantly aids readers' comprehension.

Texts that are difficult to read are said to have high grade levels while those that are easy to read have low grade levels. This is because the readability of any given text is assigned in relation to the student classification system of progressive grade levels or classes from 1 through 17. *Readability* is concerned with the matching readers to appropriate texts (Crossley et al., 2019). Traditionally, this involves assigning a numerical difficulty rating to a text after applying a readability formula (Crossley et al., 2019; Fry, 2002). This numerical score is equated to a school grade level. Readability can therefore be defined as the degree to which readers, in a specified school grade level find a text difficult or comprehensible. The definition can be extended thus: readability of a text is the years and level of education that are required in order to comfortably read that text and make meaning of it.

Concerns over readability are especially germane in the Ghanaian context in view of the fact that the English Language remains a second language to indigenous Ghanaians. The typical indigenous Ghanaian Senior High School student is, in consequence, a second-language learner (L2) in the context of science education. In fact, Yeboah-Banin et al. (2018) declared that most students at the secondary schools are still in the mesolect level of English proficiency, which means that these students have generally a proficiency level that is below formal or high-standard. Hence, in Ghana, difficulties in learning Science may be attributed to English, the language of instruction, not being the primary language. Such difficulties may also be coincidental with the difficulty of the science reading material. The likely outcome is that no meaningful learning takes place because many students attempt to learn Science by rote. It is necessary, therefore, to deliberately make textbooks supplied to Ghanaian secondary schools linguistically friendly.

It has been established that matching learning materials to the reading abilities of learners is an important way to achieve the stated objectives of educational curricula (Al-Jawarnah, 2008). In order to meet the purpose for which Science textbooks are designed, these textbooks should be appropriate for the students to use so that they can benefit from them. In view of this, the readability of these textbooks is an important avenue for researchers to pursue. Yet, researchers have often found that science textbooks are written at reading grade levels that are above the abilities of the students for which the books are written (Akinbobola, 2015; Kasule, 2011; Letsoalo, 1996; Omebe, 2014, 2015; Sibanda, 2013; Van Heerden, 2010; William & Dorcas, 2019).

More related to the present work is a study on the readability of science textbooks written and published by the Ghana Association of Science Teachers (GAST) (Gyasi, 2013). In that work, Gyasi showed that the GAST-written Senior High School Physics, Biology, Chemistry and Integrated Science textbooks were difficult to read for SHS students; in fact, the Integrated Science text was the most difficult to read. Despite the relevance of Gyasi's work, it only evaluated science textbooks published by a private entity. There still remains an important gap: there has been no study on readability of Science texts issued by Ghana's Ministry of Education (MoE) to Senior High School students as part of Ghana's Free Senior High School (SHS) program. This study, therefore, sought to fill this gap by using readability indexes (RI) to provide an objective measure of the reading grade levels of the Integrated Science textbooks currently in use in Ghana's SHS. The study was designed to answer these research questions: (1) What are the readability levels of the three Senior High School Integrated Science textbooks issued by the Government of Ghana? (2) How does reading difficulty progress with increasing grade of the three Integrated Science textbooks?

Literature Review

This section presents the theoretical underpinnings and related literature for this work.

Theoretical Underpinnings

This study was guided by Cognitive Load Theory (CLT) by John Sweller. CLT was proposed by John Sweller in 1988 to explain and predict how the cognitive load involved in learning could be a hindrance to a learners' processing of new information and creating long-term memories. Cognitive load is the mental processing effort that is associated with a task or a learning process. The basic premise of Sweller's CLT is that elements that are needlessly complex or that take away a learner's attention from information that is being learnt will increase the learner's cognitive load as the learner processes that information (Sweller, 1994). The theory assumes that a learner has a working memory with limited capacity and a long-term memory that is practically limitless in capacity (Sweller et al., 1998). CLT has over the years proved to be an important guideline in the presentation of information in ways that enable learners to boost their intellectual performance. According to CLT, cognitive load may be presented in one of three forms: intrinsic, extrinsic/ extraneous and germane. In this work, the interest is primarily on extrinsic cognitive load.

Intrinsic cognitive load is the mental processing demand made on a learner by a characteristic that is inherent in the information being processed or learnt. The amount of intellectual effort that a learner needs to exert is a function of the complexity or difficulty of the task being tackled. Intrinsic cognitive load is not particularly of interest in this work because it cannot be eliminated easily. To illustrate in context, it is assumed that word length and familiarity are factors of reading difficulty and by extension, comprehension of text. It is also known that science texts, by their nature, tend to contain unfamiliar and complex words. This means that science texts should generally present learners with high cognitive loads. It makes sense to eliminate difficult scientific vocabulary, then, in order to lower the cognitive exertion required to deal with science texts. However, this is not necessarily ideal, because eliminating scientific vocabulary may not necessarily make a text desirable or interesting (Maxwell, 1978). Moreover, less complicated words do not necessarily make texts easier to understand because the scientific use of the words and the concepts presented by the words will always be difficult for a beginning scientist (Burton, 2011) who has not acquired the necessary schema (Sweller, 1994). Besides, introducing learners to complex scientific vocabulary may build their confidence in the field, enhance future comprehension (because they will build the needed schema), and facilitate their acceptance into the science community (Burton, 2011). So, science texts will always offer higher intrinsic cognitive load, at least, where vocabulary is concerned.

However, the amount of vocabulary to present to students in any learning instance can be controlled by means of an instructional design. This is in agreement with Sweller's definition of extraneous cognitive load (Chandler & Sweller, 1991; Paas et al., 2003; Sweller, 1994, 2011; Sweller et al., 1998). Extraneous cognitive load consists in what is imposed on the learner by the teacher, or in the context of this study, the Integrated Science textbook writers. Extraneous cognitive load increases with ill-designed instructional methods.

In Swellers's view, the elements' interactivity affects the cognitive load. Interactivity is the familiarity and possible difficulty the text pose to readers due text characteristics. For Sweller, the knowledge of the learner and the characteristics of the material must be taken into consideration in developing schema and automation. The elements' interactivity can encourage either simultaneous processing or component-based processing. Therefore, total cognitive load is an amalgam of at least two quite separate factors: extraneous cognitive load which is artificial because it is imposed by instructional methods and intrinsic cognitive load over which instructors have no control because it is imposed by text elements.

The primary determinant of intrinsic cognitive load is element interactivity. If the number of interacting elements in a content area is low, it will have a low cognitive load. But if the material has high interacting elements, there will be a high cognitive load generated by the materials. This implies that relieving the burden of lexical density and syntactical complexity may solve the problem of cognitive load. This theory is vital because it helps the researcher to predict the text difficulty based on the text characteristics. The measure of readability shows the possible level of linguistic complexity of the selected texts. High scores will imply, by this theory, that the text is not easily understandable while lower score will predict that the text will be understandable. Complex language requires more processing effort. Therefore, linguistic complexity of the science textbook, if high, will lead to more processing effort, thereby impeding comprehension.

Ghana's Senior High School Integrated Science Textbooks

Ghana adopted a free SHS education policy in 2017. The primary aim of this policy was to guarantee SHS education for all qualifying students by removing the direct cost implications to parents. In order to drive this agenda, the Government of Ghana took the responsibility of all or almost all costs that should have been borne by students and their parents. These costs include the costs of textbooks.

The Integrated Science Textbooks now being used in Ghana's SHS are part of the curricular materials that the government is making available to students without charge. There are three such textbooks (Volumes 1, 2 and 3), each volume presumably designed and written to correspond to the curriculum requirements of one level of senior high school (SHS 1, 2 and 3). The textbooks were issued by the Ministry of Education of the Republic of Ghana to all SHSs in the country to serve as a common means of teaching according to the national curriculum. All three textbooks are written by Nartey, Addison, Nii Moi and Asiam. The books were first published in Ghana by Sub-Saharan Publishers in 2016.

The objective of the authors of the Integrated Science textbooks was to provide science learning to students in order to engender in them some facility for understanding the world around them and for applying scientific principles to their everyday activity. It is without argument that building such an aptitude for scientific understanding and endeavor will require the comprehension of what is taught in the science textbooks. However, if understanding is the objective for reading the textbooks, then we should be interested in measuring the ease with which the texts may be read. It is not enough to say that the textbooks are easy or difficult; there is the need for reference points or scales on which to judge the textbooks.

Methodology

Design

This work is descriptive research. Descriptive research provides a picture of a phenomenon as it naturally occurs (Bhattacherjee, 2012; Howitt & Cramer, 2020; Tavakoli, 2012). The study was descriptive in that it sought to describe the linguistic complexity of the textbooks with keen interest on their readability and lexical density. The readability scores of the textbooks were compared.

Text Selection

Simple random sampling was used to select five units or chapters from each of the three textbooks. Judgmental or criterion-based sampling was used to select blocks of text from the randomly selected units. Criterion-based sampling is a non-probability procedure in which the cases to be included in the sample are selected based on predetermined criteria (Cohen et al., 2018; Tavakoli, 2012). The criteria for selection of text were as follows:

1. That the selected portions comprised mostly text and were low on formulas, scientific notation and diagrams.
2. That the selected blocks of text were contextually complete, that is, not requiring reference to tables, diagrams, pictures or other paragraphs to make sense.
3. That the selected blocks of text did, as much as possible, not belong to bulleted or numbered lists.

The authors developed these criteria based on their understanding that readability formulas were designed to work on prose (Redish, 1981) and that bulleted lists, tables, equations and headings were not among the materials used to develop the formula.

From each of the sampled units, selected texts were to be no less than 300 words. Where necessary, blocks of texts were selected from various locations within a unit to meet the $x \geq 300$-word requirement.

The word count requirement was justified by research findings (from testing technical standards) that suggested that word counts for sample texts used for readability estimates should be between 500 and 900 (Zhou et al., 2017). However, for some heavily illustrated sampled units, and also from units with extensive bulleted lists, it was often difficult to reach the 500-word count. Therefore, the researchers set the minimum requirement at 300 words.

The sampled texts were cleaned to remove headings and to replace contractions, abbreviations, elisions and initialisms with their full forms. For in instance, "etc." was replaced by "and so on." Further, bracketed scientific notations were removed from the texts. This is because computational readability formulas calculation considers every full stop as an end of sentence; hence that would affect the number of sentences that should have been calculated to return a reading score. Screening the texts to remove it is to improve the accuracy of the measure and test score reliability.

Readability and Lexical Density Testing

Readability score for each sampled text was generated by feeding the sample into the online readability and lexical density calculator at https://www.online-utility.org. The scores were recorded in Microsoft Excel. For each sampled text, three readability indexes were used to test for difficulty. Three indexes were used for the sake of reliability of conclusions. Each readability index had a different formula for assessing reading difficulty. So, if all three indexes agreed on the difficulty of a text, for example, then the consensus would be that the text is indeed difficult, and not just difficult on a particular index but easy on others. The researchers made this choice of redundancy in testing in order to assure that the reading difficulties of the textbooks were consistent across different readability tests.

Statistical Treatment of Data

IBM® SPSS® Statistics version 20 was used to analyze data. First, simple descriptive statistics were run in order to organize and summaries the characteristics of the sampled text. Secondly, the authors ran the Shapiro-Wilk test of normality. Parametric tests of significance require that the distribution of the sample be normal or near to normal. This requirement is especially important where, as in this work, the researchers had to work with small sample sizes (Tavakoli, 2012). Another requirement of parametric tests is the symmetry of the distributions, or the homogeneity of variance, among the various groups under study. The authors ran Levene's test of homogeneity of variance.

Thirdly, a number of Analysis of Variance procedures, both parametric and non-parametric, were run to test the statistical significance of differences, if any, among the readability scores of the textbooks. The use of both categories of inferential statistics was for confirmation purposes. This was especially deemed necessary because, for Book 2, data for the Gunning Fog Index, the SMOG Index and lexical density were not normally distributed. Also, texts from randomly selected chapters were selected by a non-probability approach. Some authors (e.g. Cramer & Howitt, 2004) recommend that both parametric and non-parametric analyses be done to ensure that findings and conclusions are not affected by outliers.

Results and Discussion

The study sought to examine the readability of the currently-in-use SHS Integrated Science textbooks in Ghana. Three readability indexes were used: Gunning Fog, SMOG and the Flesch-Kincaid Grade Level score. This section provides a presentation of results of the data analysis and a discussion of those results under two main headings corresponding to the study's research questions. First, the readability levels of the textbooks are discussed and then the progression of reading difficulty among the textbooks is discussed.

Research Question 1: What are the readability levels of the three Senior High School Integrated Science textbooks issued by the Government of Ghana?

This research question sought to establish the readability levels of the three Senior High School Integrated Science textbooks issued by the Government of Ghana.

Table 1 presents statistics describing the readability of the SHS 1 Integrated Science textbook.

According to the Gunning Fog Index, the SHS Integrated Science Book 1 would require the aptitude of a university freshman (in their 13th year of formal schooling) to read and understand (Mean= 13.2280, SD= 2.72593).

Table 1: Descriptive Statistics of Readability Scores- Book 1

Readability Index	n	Mean score	Std. Dev.
Gunning Fog Index	5	13.2280	2.72593
SMOG Index	5	13.1380	1.42177
Flesch-Kincaid Grade Level	5	10.9820	1.28659

Table 2: Descriptive Statistics of Readability Scores- Book 2

Readability index	n	Mean score	Std. Dev.
Gunning Fog Index	5	11.5300	2.98201
SMOG Index	5	11.9220	2.18605
Flesch-Kincaid Grade Level	5	10.3060	2.61064

Table 3: Descriptive Statistics of Readability Scores- Book 3

Readability index	n	Mean score	Std. Dev.
Gunning Fog Index	5	11.1160	2.46174
SMOG Index	5	11.6720	1.59280
Flesch-Kincaid Grade Level	5	10.1460	1.61786

This means that the text is too difficult for a student in SHS 1 (in their 10th year of formal schooling) for whom the text is written. A similar score was recorded on the SMOG Index scale (Mean= 13.1380, SD= 1.42177). The Flesch-Kincaid Grade Level index placed the score of the text at approximately 11 (Mean= 10.9820, SD= 1.28659). This means that, on the Flesch-Kincaid Grade Level index, the text of the SHS Integrated Science Book 1 is a grade above the reading ability of its target audience.

Table 2 presents statistics describing the readability of the SHS 2 textbook. According to the Gunning Fog index, in table 2, the mean readability score of Book 2 of the SHS Integrated Science text was 11.5300 (SD= 2.98201). On the SMOG Index, the mean readability of Book 2 was 11.9220 (SD=2.18605). The Gunning and SMOG index results suggest that the SHS 2 text is more suited to students with approximately 12 years of formal education, placing the material a grade above the expected reading and comprehension abilities of its target audience. The Flesch-Kincaid Grade Level Formula placed the text at a mean of 10.3060 (SD= 2.61064), suggesting that the text should be suitable for a student with 10 years of formal schooling, which a Ghanaian student in SHS 2 has acquired.

Table 3 presents statistics describing the readability of the SHS 3 Integrated Science textbook.

According to the results in Table 3, both the Gunning and the SMOG indices placed the reading difficulty of the SHS 3 textbook at approximately 11, suggesting that students with about 11 years of formal education should be able to comfortably read and understand the text. Considering SHS 3 students are in their 12th year of formal education, these results indicated that the textbook should not present reading and comprehension problems to its intended audience. The Flesch-Kincaid Grade Level index pegged the readability of the SHS 3 science text at even lower grade level, by returning a figure that suggests that the text is suited to students in SHS 1 (equating to the 10th year of formal education in Ghana).

Book 1 was written beyond the reading and comprehension of students in SHS 1. In fact, the readability indexes placed the text at the university level and showed that the text may be too confusing to students for whom the text was written. This situation is problematic. Science learning among students for whom English is a second language is an acknowledged challenge because of the higher cognitive requirements involved (Lemke, 1997; Wellington & Osborne, 2001). Therefore, to further introduce extrinsic elements, such as higher vocabulary loads, authors should present learners with higher cognitive loads that are not germane to learning. This is because the gap in students' reading proficiency and the readability of their study materials has consequences for the amount of cognitive resources required to parse the text (Chandler & Sweller, 1991; Paas et al., 2003; Sweller, 1994, 2011; Sweller et al., 1998).

For Book 2, mean readability scores showed that the text may be better suited to its target audience than Book 1 was. The mean scores showed the difficulty level of the text was just a grade above SHS 2. However, wide variations in difficulty, as indicated by a relatively large standard deviation in results from, at least, one index indicated that some units in the textbooks may be too difficult for SHS 2 students. Book 3 text was, interestingly, found to be written at a mean difficulty level of SHS 2. While variations in the results from one of the indexes showed that some portions of the SHS 3 text may be suited to university students, the consensus was that Book 3 was generally written below the reading and comprehension abilities of the target audience. The readability levels of Books 2 and 3 should help the target students in their studies. As Spinks and Wells (1993) found in a study of college business students, the use of more readable textbooks correlated with higher grades and higher completion rates. This is because reading textbooks written at ideal readability levels should not require present learners with high cognitive loads that make learning difficult (Chandler & Sweller, 1991; Paas et al., 2003; Sweller, 1994, 2011; Sweller et al., 1998). The lower linguistic complexity of these textbooks does not pose further hurdles to ESL students (Lemke, 1997; Wellington & Osborne, 2001) learning science in Ghana's Senior High Schools. Texts that are easier to read and comprehend will likely not encourage rote learning as would be the case for difficult texts that impede meaningful learning (Anamuah-Mensah & Benneh, 2006; Jones, 2008). It has been established that matching learning materials to the reading abilities of learners is an important way to achieve the stated objectives of educational curricula (Al-Jawarnah, 2008). Therefore, the Integrated Science textbooks supplied as part of Ghana's Free Senior High School Policy should generally be helpful to promoting enhanced learning outcomes.

Research Question 2: How does reading difficulty progress with increasing grade of the three Integrated Science textbooks?

An Inferential statistics technique was used in order to test the differences in reading difficulty among the textbooks. It was rationally expected that, since any rise in grade level represented a linear increase in number of years a student would have schooled, the textbooks for different grades would be significantly different in their difficulty levels.

Table 4: Shapiro-Wilk Tests of Normality

	TEXTBOOK	Shapiro-Wilk		
		Statistic	*Df*	*Sig.*
Gunning Fog Index Score	BOOK 1	0.831	5	0.142
	BOOK 2	0.670	5	0.005
	BOOK 3	0.955	5	0.771
SMOG Index Score	BOOK 1	0.890	5	0.356
	BOOK 2	0.724	5	0.017
	BOOK 3	0.935	5	0.628
Flesch-Kincaid Grade Level Score	BOOK 1	0.857	5	0.218
	BOOK 2	0.777	5	0.052
	BOOK 3	0.925	5	0.561

Alpha level= 0.05

Further, it was expected that the difficulty levels of the books would rise with the grade levels.Therefore, statistically significant differences in readability would likely indicate progression in reading difficulty of the textbooks.

Tests of Normality of Readability Scores

Table 4 presents the results of Shapiro-Wilk tests for normality of distribution of readability scores of the three textbooks over three readability indexes. The test of normality showed that scores for Books 1 and 3 from all three indexes had a normal distribution. From Table 4, it can be seen that for each of these textbooks, the significance level reported is higher than the alpha value of 0.05 across all three indexes. Scores for Book 2 from the Gunning Fog and the SMOG indexes, however, did not have a normal distribution. Table 4 shows that their significance levels were below the 0.05 alpha level. This departure from normalcy justified the use of non-parametric tests in addition to the parametric tests in assessing statistical differences.

Test of Homogeneity of Variances

Table 5 presents the results of the tests of homogeneity of the variances in the readability scores, using the Levene's test.

Table 5: Levene's Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Gunning Fog Index Score	0.072	2	12	0.931
SMOG Index Score	0.244	2	12	0.787
Flesch-Kincaid Grade Level Score	0.761	2	12	0.488

Alpha level = 0.05

Table 6: One-Way Analyses of Variance: Readability Scores

		Sum of squares	Df	Mean square	F	Sig.
Gunning Fog Index Score	Between Groups	12.525	2	6.263	0.839	0.456
	Within Groups	89.533	12	7.461		
	Total	102.058	14			
SMOG Index Score	Between Groups	6.151	2	3.075	0.988	0.401
	Within Groups	37.349	12	3.112		
	Total	43.500	14			
Flesch-Kincaid Grade Level Score	Between Groups	1.969	2	0.985	0.266	0.771
	Within Groups	44.353	12	3.696		
	Total	46.322	14			

The test of homogeneity showed that the variances among the means of the scores on the various indexes would be homogenous at 0.05 alpha level. For each of the indexes, the significance level, as reported in Table 5, was higher than the 0.05 alpha level. Parametric tests of differences in means were therefore suitable for comparison of means in this study.

Analysis of Variance between Readability Levels of the Textbooks

The study used the One-Way Analysis of variance (ANOVA) analysis to test the equality of mean readability scores. This comparison of means was conducted for scores from each of the readability indexes used. In Table 6 presents a test for significant differences among the difficulty levels of the Integrated Science textbooks. It should be noted that the results presented in Table 6 are the results of a parametric test (results for the non-parametric analyses are presented in table 7.

As Tables 6 and 7 show, there were no significant differences among the mean readability scores, from Gunning Fog index, of the three textbooks (p= 0.456). There were no significant differences among the mean readability scores, from the SMOG index, of the three textbooks (p= 0.401). There were no significant differences among the mean readability scores, from the Flesch-Kincaid Grade Level formula, of the three textbooks (p= 0.771).

It is interesting to note that from the findings of this study, Book 1 was the most difficult textbook for its target audience, according to the readability scores. It would stand to reason for Book 1 to be the easiest to read and comprehend by its target audience; students in SHS 1 have only just entered Senior High School, and it would be reasonable for them to be eased into the core science curriculum. Thereafter, reading difficulty could be raised with increasing grade level.

Yet, the statistical tests showed that the three textbooks did not differ significantly from each other in terms of their reading difficulty as determined by the Gunning Fog, SMOG and Flesch-Kincaid Grade Level indexes. This means that there was no discernible progression in reading difficulty among the textbooks as the grade level increased. A textbook for a higher grade level was not necessarily more difficulty to read than the one for the preceding grade level. The implication is that the authors may not have attempted to provide some sort of difficulty progression to the science text so that reading difficulty level would rise with grade level.

Table 7: Welch and Brown-Forsythe tests of equality of means

	Test	Statistic[a]	df1	df2	Sig.
Gunning Fog Index Score	Welch	.817	2	7.951	0.476
	Brown-Forsythe	.839	2	11.718	0.456
SMOG Index Score	Welch	1.211	2	7.797	0.348
	Brown-Forsythe	.988	2	10.454	0.405
Flesch-Kincaid Grade Level Score	Welch	.412	2	7.539	0.676
	Brown-Forsythe	.266	2	8.776	0.772

a. Asymptotically F distributed.

Sentences should have been progressively sophisticated as children grow, with increases in complex modifications such as modifiers, verbs in serial expression, etc. As people grow, their ability to tackle greater syntactic complexity and therefore their ability to read more difficult texts can be expected to increase. This is in keeping with the report by Sticht and Armstrong (1994) on how age affects performance on the same test items.

They reported that as children grew up into adults and attended school along the way, they grew increasingly more literate. Therefore, it is reasonable to expect a progression in reading difficulty in the Integrated Science Textbooks in response to increasing reading aptitude among Senior High School students.

Conclusions and Recommendation

The study concludes that while science textbooks for SHS 2 and 3 are suitable for their intended audience, the readability of Book 1 is significantly above the reading level of students in SHS 1. Therefore, the study concludes that the Integrated Science textbooks used in Ghana's Senior High Schools may not be appropriate for readability. The modest attention to readability may have created a comprehension barrier that would hinder senior school students from deriving maximum benefit from using the textbooks for self-directed study. The study recommends further evaluation of all the textbooks and particularly of Book 1 for possible revision of the material. Such revision should potentially help students to achieve the intended meaningful learning.

References

Akinbobola, A. O. (2015). Guidelines on how to read a physics textbook and the assessment of the readability of recommended physics textbooks in secondary schools in Osun State of Nigeria. Journal of Education and Practice, 6(6), 32–39. https://shorturl.at/rvDMN.

Al-Jawarnah, M. (2008). The readability level of social and National Education textbooks for fourth primary grade in Jordan. Journal of Educational and Psychological Sciences., 4(2), 124–136.

Anamuah-Mensah, J., & Benneh, M. (2006). Particular issues of teacher education in Ghana. Deshawn Alridge.

Azure, J. A. (2015). Senior high school students' views on the teaching of Integrated Science in Ghana. Journal of Science Education and Research, 1(2), 49–61.

Bhattacherjee, A. (2012). Social science research: Principles, methods, and practices (2nd ed.). University of South Florida Scholar Commons.

Burton, R. S. (2011). Bridges or barriers: Analysis of logodiversity in college biology textbooks. Bioscene: Journal of College Biology Teaching, 37(1), 3–7.

Chambliss, M. J. (2002). The characteristics of well-designed science textbooks. In J. Otero, J. A. León, & A. C. Graesser (Eds.), The psychology of science text comprehension (pp. 51–72). Lawrence Erlbaum Associates.

Chambliss, M. J., & Calfee, R. C. (1989). Designing science textbooks to enhance student understanding. Educational Psychologist, 24(3), 307–322. https://doi.org/10.1207/s15326985ep2403.

Chandler, P., & Sweller, J. (1991). Cognitive Load Theory and the Format of Instruction. Cognition and Instruction, 8(4), 293–332. https://doi.org/10.1207/s1532690xci0804_2.

Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education (8th ed.). Routledge.

Cramer, D., & Howitt, D. (2004). The SAGE dictionary of statistics. Sage Publications. https://doi.org/10.4135/9780857020123.

Crossley, S. A., Skalicky, S., & Dascalu, M. (2019). Moving beyond classic readability formulas: new methods and new models. Journal of Research in Reading, 42(3–4), 541–561. https://doi.org/10.1111/1467-9817.12283.

Fisher, M. R. (2018). Evaluation of cost savings and perceptions of an open textbook in a community college science course. American Biology Teacher, 80(6), 410–415. https://doi.org/10.1525/abt.2018.80.6.410.

Fry, E. (2002). Readability versus leveling. The Reading Teacher, 56(4), 286–291. https://doi.org/10.1002/JAAL.00033.

Fuchs, E., & Bock, A. (2018). Introduction. In E. Fuchs & A. Bock (Eds.), The Palgrave Handbook of Textbook Studies. (pp. 1–9). Palgrave Macmillan.

Gyasi, W. K. (2013). The role of readability in science education in Ghana: A readability index analysis of Ghana Association of Science Teachers textbooks for senior high school. IOSR Journal of Research & Method in Education (IOSR-JRME), 2(1), 9–19. www.iosrjournals.org.

Howitt, D., & Cramer, D. (2020). Research methods in psychology (6th ed.). Pearson.

Jones, K. R. (2008). Will Education be powerful enough to provide satisfying employment and economic stability? Career Development: NCDA Magazine, 22–28.

Kasule, D. (2011). Textbook readability and ESL learners. Reading and Writing, 2(1), 63–76.

Lemke, J. L. (1997). Cognition, context, and learning: A social semiotic perspective. In D. Kirshner & J. A. Whitson (Eds.), Situated Cognition: Social, Semiotic, and Psychological Perspectives (pp. 37–56). Lawrence Erlbaum Associates, Inc. https://shorturl.at/dqBWY.

Lemke, J. L. (1998). Teaching all the languages of science: Words, symbols, images, and actions. Conference on Science Education, Barcelona, Spain, 483–492. https://shorturl.at/nxAH.

Letsoalo, M. B. (1996). Improving text for English as a second language biology pupils. Journal of Biological Education, 30(3), 184–188. https://doi.org/10.1080/00219266.1996.9655501.

Maxwell, M. (1978). Readability: Have we gone too far? Journal of Reading, 21(6), 525–530.

Nunoo, F. K. N., Anane-Antwi, E., Mensah, D. P., Nunoo, I. E., & Brew-Hammond, A. (2022). Readability analyses of Integrated Science textbooks for Junior High Schools in Ghana. African Journal of Educational Studies in Mathematics and Sciences, 17(2), 61–72. https://doi.org/10.4314/ajesms.v17i2.6.

Omebe, C. A. (2014). Textbooks in use in Ebonyi State. International Journal of Scientific & Engineering Research, 5(12), 1059–1062.

Omebe, C. A. (2015). Using Cloze procedure in assessing the readability of approved chemistry textbooks in Ebonyi State secondary schools in Nigeria. International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS), 3(10), 97–104.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive Load Theory and instructional design: Recent developments. Educational Psychologist, 38(1), 1–4. https://doi.org/10.1207/S15326985EP3801_1.

Pelekh, Y. (2020). Urgent issues and modern challenges of higher education. Problems of Education In the 21st Century, 78(5), 20–22. https://doi.org/10.33225/pec/20.78.671.

Redish, J. C. (1981). Understanding the limitations of readability formulas. IEEE Transactions on Professional Communication, PC-24(1), 1981. https://doi.org/https://doi.org/10.1109/TPC.1981.644 7824.

Robinson, T. J., Fischer, L., Wiley, D., & Hilton, J. (2014). The impact of Open textbooks on secondary science learning outcomes. Educational Researcher, 43(7), 341–351. https://doi.org/10.3102/0013189X14550275.

Sibanda, L. (2013). A case study of the readability of two grade 4 natural sciences textbooks currently used in South African schools. [M.Ed., Rhodes University]. http://hdl.handle.net/10962/d1006083.

Spinks, N., & Wells, B. (1993). Readability: A textbook selection criterion. Journal of Education for Business, 69(2), 83–87. https://doi.org/10.1080/08832323.1993.10117662.

Sticht, T. G., & Armstrong, W. B. (1994). Adult Literacy in the United States: A Compendium of Quantitative Data and Interpretive Comments. Washington, DC: National Institute for Literacy.

Sweller, J. (1994). Cognitive Load Theory, learning difficulty, and instructional design. Learning and Instruction, 4, 293–312. http://c oral.ufs m.br/tielletcab/Apostilas/cognitive_load_theory_swell er.pdf.

Sweller, J. (2011). Cognitive Load Theory. In J. P. Mestre & B. Ross (Eds.), Psychology of Learning and Motivation (pp. 37–76). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-387691-1.00002-8.

Sweller, J., van Merrienboer, J. G., & Paas, F. G. W. C. (1998). Cognitive Architecture and Instructional Design. Educational Psychology Review, 10(3), 251–296.

Tárraga-Mínguez, R., Tarín-Ibáñez, J., & Lacruz-Pérez, I. (2021). Analysis of word problems in primary education mathematics textbooks in Spain. Mathematics, 9(17). https://doi.org/10.3390/math9172123.

Tavakoli, H. (2012). A dictionary of research methodology and statistics in applied linguistics. Rahnama Press.

Van Heerden, L. L. (2010). An investigation into the readability of the grade 10 physical science textbooks: a case study. [M.Ed.]. Rhodes University.

Wellington, J., & Osborne, J. (2001). Language and literacy in science education. Open University Press.

William K. G., & Dorcas P., S. (2019). Readability of English language textbooks for diploma students of the University of Cape Coast. International Journal of Research Studies in Language Learning, 8(1), 107–115. https://doi.org/10.5861/ijrsll.2019.3008.

Yeboah-Banin, A. A., Fosu, M., & Tsegah, M. (2018). Linguistic complexity and second language advertising audiences: Is there a case for linguistic exclusion? Journal of Communication Inquiry, 42(1), 70–90. https://doi.org/10.1177/0196859917737292.

Yi, P. H., Golden, S. K., Harringa, J. B., & Kliewer, M. A. (2019). Readability of lumbar spine MRI reports: Will patients understand? American Journal of Roentgenology, 212(3), 602–606. https://doi.org/10.2214/AJR.18.20197.

Zhou, S., Jeong, H., & Green, P. A. (2017). How consistent are the best-known readability equations in estimating the readability of design standards? IEEE Transactions on Professional Communication, 60(1),97111.https://doi.org/10.1109/TPC.2016.263572 0.