Readability: A Factor in Textbook Evaluation

Yvette M. d'Entremont

Yvette d'Entremont is a doctoral candidate in the Department of Secondary Education at the University of Alberta.

Selecting an appropriate text for a school mathematics program is an important task and should not be taken lightly. Because mathematics has a language of its own, one of the factors that should be considered in textbook selection is readability.

Mathematics teachers are aware that reading mathematics material is different from reading other subject matter. Reading in mathematics is more than reading words. It involves decoding the words; decoding and interpreting the various mathematical symbols; and being able to interpret, comprehend and solve mathematical sentences and phrases. The mathematics textbook serves as an aid in developing language in mathematics.

One way in which students acquire skills and knowledge is by reading instructional materials; therefore, they must have textbooks that are easy to read and comprehend. Progress in learning mathematics and the language of mathematics will be achieved if the reading level of the textbooks is appropriate to the grade or course for which the texts are intended.

Departments of education and teachers are faced with an ever-increasing flood of printed materials, which differ widely in content, style and difficulty, and from which selections have to be made. In this situation, readability formulas may help by providing teachers with an additional guide for selecting suitable material. The textbook that is most effective is the one in which the author, through his or her writing style and vocabulary, produces a text with a reading level that is matched with the reading level of the student (Kennedy 1974).

In preparing new textbooks, the readability level of the text is considered by some publishers. In 1982, the readability level of *Starting Points in Math 10* was analyzed. J.E. Freeman, associate program manager for Ginn and Company (publishers of *Starting Points*), stated that it is the company's policy to establish readability levels of textbooks by the Fry Graph but that provincial departments of education that purchase books do not inquire about the readability level of particular texts.

When considering whether to adopt a new mathematics textbook, Alberta Education does not apply readability formulas but pilots or field tests the book. Publishers are invited to submit textbooks that they feel will fit the scope and sequence of the curriculum sent to them by Alberta Education. A committee of teachers from across the province then evaluates the textbooks submitted by the publishers and chooses a number of them to field test. After piloting the textbooks, the teachers come together to discuss the books and the program and how they fit together. They select the books that will be listed as "basic resources." Schools then select the books that they wish to use from the list of basic resources (Jim Neilsen 1988).

Many students experience difficulties in comprehending the explanations and problems found in mathematics textbooks. Concern about this has led me to assess the readability level of the text referred to earlier, *Starting Points in Math 10,* which I use with my Grade 10 students.

The readability level of particular textbooks can be determined by using readability formulas. Applying formulas usually involves selecting a sample from a text, counting some easily identifiable characteristics such as the average number of words per

sentence or the proportion of polysyllabic words in the sample, and performing a calculation to produce a score (Gilliland 1972). Thus, readability formulas are based on correlational data, the correlation between sentence length and passage reading difficulty.

My objectives were to ascertain the readability level of the text by using two readability formulas, the Fry Readability Graph and McLaughlin's SMOG Grading Formula, and by administering cloze tests. A readability formula is a formula that is intended to provide quantitative objective estimates of the difficulty of reading (Klare 1963).

Three passages were selected at random from the text:

1. Finding the Equation of a Line, Given Two Points (p. 36)
2. Adding and Subtracting Rational Expressions (p. 288)
3. The Pythagorean Theorem (p. 257).

The Fry Readability Graph, Figure 1, (Fry 1968) and McLaughlin's SMOG Grading Formula were applied on each passage selected.

Figure 1

Grade	Average Number of Sentences per 100 words	Average Number of Syllables per 100 words
1	14.3	120
3	8.6	123
6	5.8	129
9	4.5	149
12	4.0	162

Extracted from Fry's Readability Graph. [From "Reading Level Determination for Selected Texts" by K. Kennedy, *The Science Teacher* 41 (March 1974): 26.]

The Fry Readability Graph uses two factors to determine reading level: the average number of sentences per 100 words and the average number of syllables per 100 words. The intersection point of these two factors on the Fry Graph gives the grade level.

The McLaughlin SMOG Grading Formula, developed in 1969 by G. Harry McLaughlin, is based on only one factor: the number of words having three or more syllables in 30 selected sentences. The grade level is calculated by adding "3" to the nearest appropriate square root of the polysyllabic word count.

The Fry Readability Graph and McLaughlin's SMOG Grading Formula were not designed for use with mathematics materials, but they have been modified to measure the readability of a variety of mathematics books. In applying the formulas to mathematics textbooks, the samples selected should include only sentences. Non-sentence material such as pure computation, equation-solving, geometric proofs, titles of chapters and illustrative problems are not part of the content examined (Johnson 1957).

Readability scores were calculated on the text in question using the above readability formulas. Analysis of the selected passages by use of the Fry Readability Graph produces 163.7 as the average number of syllables per 100 words, and 4.9 as the average number of sentences per 100 words. Plotting the average number of syllables per 100 words and the average number of sentences per 100 words on the Readability Graph results in an average reading level of Grade 12 for the text, *Starting Points in Math 10.*

Analysis of the same selected passages by use of the SMOG Grading Formula produces a polysyllabic word count of 105 in 30 selected sentences. Calculating the square root of 100 (the nearest appropriate figure to 105) and adding 3 to the square root gives a figure of 13. Therefore, according to the SMOG Grading Formula, the reading level of the text in question is Grade 13.

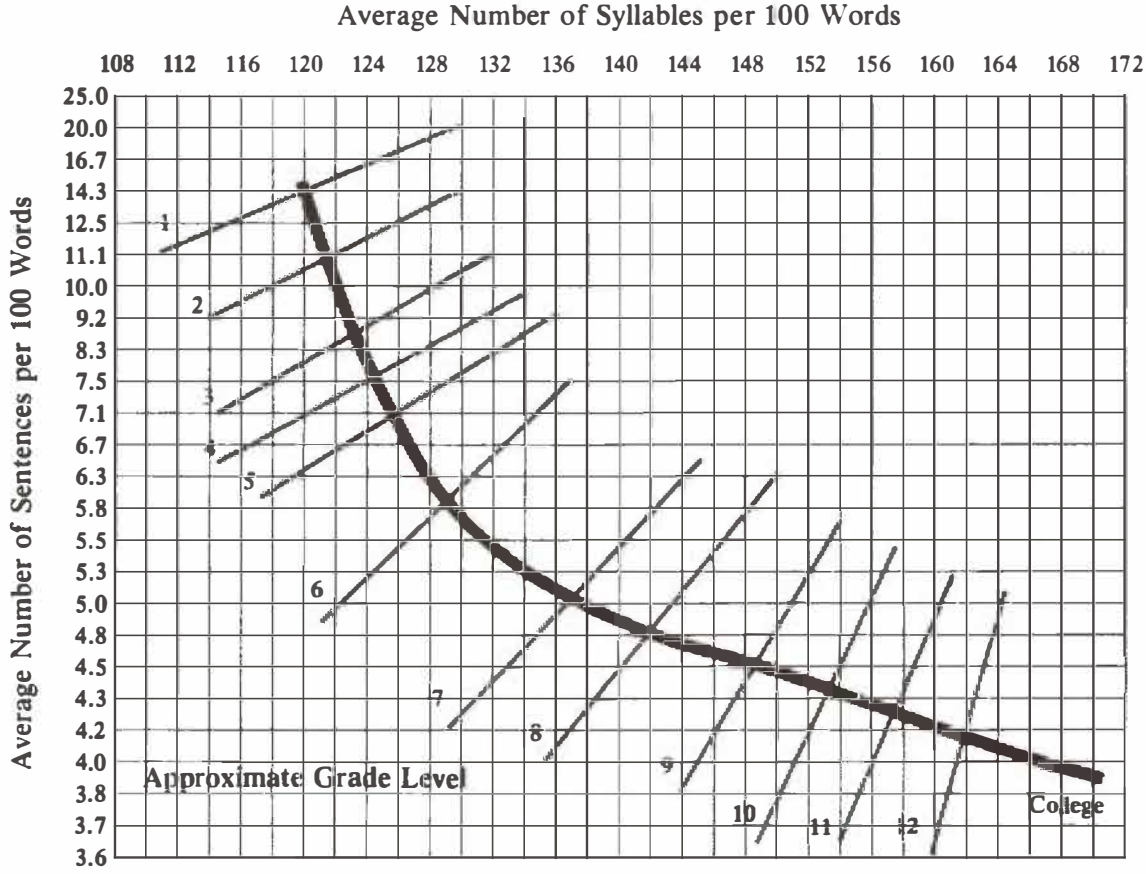
When discussing these results, one must consider the grade level of the intended user of the text as well as the accuracy of the formulas involved. Fry (1968) states that the Readability Graph results are accurate to "probably within a grade level" (p. 514). For the SMOG Grading Formula, the standard error is about 1.5, providing a range of three years (McLaughlin 1969).

The Fry Readability Graph and McLaughlin's SMOG Grading Formula are based on different prediction criteria. The Fry Readability Graph predicts the reading level that a student must have to be able to read the text with 50 to 75 percent comprehension. The SMOG Grading Formula attempts to predict the reading level necessary to read with 90 to 100 percent comprehension.

The results obtained predict that a Grade 12 reading level is required to read *Starting Points in Math 10* with 50 to 75 percent comprehension and that a Grade 13 reading level is required to read the text with 90 to 100 percent comprehension. The results

Figure 2. Fry's Readability Graph.

[From "Reading Level Determination for Selected Texts" by K. Kennedy, *The Science Teacher,* 41 (March 1974): 26.]



suggest that a reading level of Grade 13, which is three levels above the intended grade level of the user, is required to be able to read and fully understand the text.

The text was further tested by evaluating individual students' comprehension. The students were divided into three groups and randomly assigned a cloze test on the same passages selected for the readability formulas. A cloze test is a mutilated passage in which every fifth word or symbol from the passage has been deleted and replaced with a blank. In contructing cloze tests for mathematics texts, not only words but symbols such as >, % and 5 may be deleted. The student is then required to fill each blank with the exact word or symbol according to the original text material. The cloze procedure allows readers to use their knowledge of language patterns and their ability to respond to contextual clues (Malo 1978).

The cloze procedure is advocated as a measure of the readability of "mathematical English" by Hater and Kane (1975). In 1970, they conducted a study to adapt the cloze procedure to the language of mathematics and to assess its behavior as a measure in that language.

The scores obtained by the students on each test were separated into three categories:

0%—43% correct—frustration level
44%—57% correct—instruction level
58%—100% correct—independent level

Bormuth (1968) found that a score of 75 percent on conventional comprehension tests is comparable to a score of 44 percent on a cloze readability test made from the same passage. The three levels listed above have been accepted as a standard when interpreting cloze test results.

The percentage score means achieved on passages from *Starting Points in Math 10* were 57.38, 55.52 and 71.50 for passages 1, 2 and 3, respectively. These scores suggest that passage 3 may have been easier than passages 1 and 2, perhaps due to familiarity with the topic (Pythagorean Theorem). Averaging the percentage score mean of each passage provides a text mean of 61.47. The text mean of 61.47 falls into the independent level, but is only slightly above the instructional level of 44 to 57 percent. Because students were familiar with the content of the cloze tests (which may have affected the scores), one can conclude with a degree of certainty that the text assessed is suitable to be used if instructional support is provided.

One must always keep in mind that readability formulas and cloze tests are tools that can be used to assess the readability level of texts. Readability scores give an approximate grade level for materials and should be used as guides rather than absolute values. Knowing the readability level of a particular text can influence whether one will adopt it for a group of students.

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