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A Computer Readability Formula Designed for Machine Scoring

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Existing computer programs that measure readability are based largely upon subroutines which estimate number of syllables, usually by counting vowels. The shortcoming in estimating syllables is that it necessitates keypunching the prose into the computer. There is no need to estimate syllables since word length in letters is a better predictor of readability than word length in syllables. Therefore, a new readability formula was computed that has for its predictors letters per 100 words and sentences per 100 words. Both predictors can be counted by an optical scanning device, and thus the formula makes it economically feasible for an organization such as the U.S. Office of Education to calibrate the readability of all textbooks for the public school system.

Coke and Rothkopf (1970) developed a computer program that determined the Flesch reading ease score of a passage. Flesh (1946) defined reading ease (RE) as $RE = 206.835 - .846\ WL - 1.015\ SL$, where WL (word length) is the number of syllables per 100 words, and SL (sentence length) is the average number of words per sentence. The essence of the Coke and Rothkopf method is a subroutine that estimates number of syllables by counting vowels. The great advantage of their subroutine is that it is less complicated than similar ones developed by Berkeley (1967), Fang (1968), and Klare, Rowe, St. John, and Stolurow (1969). The more complicated subroutines are also based upon a vowel count, but each takes into account greater or lesser numbers of exceptions to the rule, for example an exception that determines when "e" is used as a syllable nucleus and when it is used as the silent marker at the end of a word.

The major purpose of this article was to show that even efficient techniques for estimating number of syllables are not the most accurate or economical ways to obtain a reading ease score. The fatal shortcoming of the syllable count is that it requires keypunching the text into the computer; this is generally more expensive than obtaining a reading ease score by hand counting. What is needed is a formula with predictor variables suited to mechanical counting devices.

Such a formula is easy to derive. Two predictors have been shown to account for 60%–80% of the variance in most readability formulas: (a) a measure of sentence complexity usually measured by the average number of words per sentence and (b) a measure of word complexity usually measured by the average number of syllables per word. It would not be difficult to design a mechanical device that could count sentence length. One such device is an optical scanner that could count all words occurring between two periods. It would be equally simple for the same device to count word length by requiring that word length be measured in letters, not syllables.

Since the development of the Flesch readability formula, better methods for scaling passages have been devised. Given a more precise scale of complexity, prediction equations which account for more of the variance can be computed. The cloze technique provides one means for calibrating materials for complexity. Bormuth (1966) and Miller and Coleman (1967) have scaled a large number of passages using this technique. The prediction equation of the present article was based upon 36 passages scaled by Miller and Coleman. These 36 150-word passages were ranked from easy to difficult according to the scores obtained from three types of cloze tests. For one test 20% of the words were deleted. In another, only one word was deleted, while in the third test the subject had to successively guess all 150 words while being told the correct word as he proceeded through the passage. These 36 passages constituted a rather precise scale of difficulty since Miller and Coleman obtained 2,400 cloze responses on each passage—16 scores on each word in each passage.

From the original data for Miller and Coleman's (1967) 36 passages, a new prediction equation was computed with the predictors being letters per 100 words and sentences per 100

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TABLE 1

TRANSLATION OF CLOZE PERCENTAGES INTO GRADE LEVELS

Grade level	Cloze %	Grade level	Cloze %
1	80.5	9	51.3
2	76.9	10	47.7
3	73.2	11	44.0
4	69.6	12	40.4
5	65.9	13	36.7
6	62.3	14	33.1
7	58.6	15	29.4
8	55.0	16	25.8

words:

Estimated cloze %

$$= 141.8401 - .214590\,L + 1.079812\,S,$$

where estimated cloze % = percentage of deletions that can be filled in by a college undergraduate, L = number of letters per 100 words, and S = number of sentences per 100 words. The multiple R of this formula is .92; therefore these two predictors account for 85.11% of the variance among the 36 scores (the score for a passage being either its estimated cloze % or the basis for that estimate, the passage's total cloze score).[1]

A multiple R of .92 may seem rather high, but it should be noted that these passages cover an unusually wide range, stretching from first-grade material to extremely difficult technical prose. A cross-validation study by Szalay (1965) for a similar readability formula derived from this scale gave support for an R of this magnitude. The multiple R for that formula was .897, slightly less than ours since it used a less accurate indicator of word difficulty (number of one-syllable words in the passage). When Szalay cross-validated with a new set of passages, the correlation between the cloze percentage he predicted from the formula and the percentage he obtained was .88, almost no shrinkage.

[1] Miller and Coleman's most reliable measure for a passage was what they called its total score, the sum of the three sorts of cloze scores mentioned earlier. This total cloze is somewhat difficult to interpret and so an estimated cloze percentage was predicted from it: Estimated cloze = 1.4654 total cloze − .1070.

Some people may find grade levels more interpretable than cloze scores. Table 1 gives grades and corresponding cloze percentages. The 36 Miller-Coleman passages could be assigned to grade levels because 26 of them came from *Standard Test Lessons in Reading* (McCall & Crabbs, 1961) which scales its passages to grade level, while the other 10 passages came from two first-grade books and five upper-level college textbooks. The r between grade level and cloze percentage is −.88. Table 1 was derived from the following formula:

Grade level

$$= -27.4004 \text{ estimated cloze \%} + 23.06395$$

In summary, our formula provides an economical method for measuring readability mechanically with an optical scanner. It would be feasible, therefore, for an organization such as the U.S. Office of Education or the Library of Congress to use the formula to calibrate the readability of all textbooks designed for the public school system.

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