

ARTICLES

Bridges or Barriers: Analysis of Logodiversity in College Biology Textbooks

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Abstract: When selecting a textbook, college instructors must weigh a variety of factors. One is whether the text is written at a level that is accessible to one's students. An important factor in this is how many technical words are used. I developed an index to calculate logodiversity, a term I coined that reflects the number of technical words and the usage frequency of those words. The college-level animal behavior textbooks I examined varied greatly in their logodiversity. A fairly reliable substitute for the more time-consuming calculation of logodiversity is the ratio of pages in the glossary to the number of pages in the text as a whole.

Key words: textbook, readability, jargon, logodiversity

*Such an educated feller
His thoughts just came in herds
He astonished all the cowboys
With his jaw-breakin' words.*

-The Zebra Dun

Specialized language separates members of groups from non-members. Cultures, age groups, and people from different geographic regions often use knowledge of particular jargon or slang to distinguish those who belong from those who do not. Most of us have probably been in situations where we've been excluded from conversations because we did not know the specialized vocabulary of a subculture. As we stand outside the circle, group members glory in their use of their own language. We are left to figure out the meaning, wait for an interpretation, or wander off to join another group.

As jargon proliferates, science becomes more like a foreign language (Montgomery 2004). Indeed, we probably all have heard students in our biology courses make similar statements. Given enough time and practice, many students are able to join the biology in-group, but the struggle may exclude some students who would otherwise have been successful scientists.

When does the teaching of specialized science vocabulary cease to be a bridge to the world of science and instead become a barrier that prevents students from joining the profession—or even the conversation? If we are to make effective decisions about how to present material, we need to decide how much specialized vocabulary to use. We might decide “on the fly” how to say things in the classroom—even offering several wordings for the same concept—but these discussions are ephemeral. Our

textbook selection is a decision that lasts throughout the school term.

Informally reviewing a textbook may not be enough to determine readability. High school biology teachers generally are able to distinguish between more and less readable biology textbooks, but tend to underestimate how much a difficult text must be simplified in order to make it more readable (Wright and Spiegel 1984). Several readability indices have been designed for evaluating textbooks quantitatively. Most (*e.g.* Coleman-Liau, EFLAW, Flesch-Kincaid, Fog, Fry, and Raygor) are based on length of sentences and words (either characters or syllables). Armbruster *et al.* (1985) demonstrated that passages designed to score as more readable on these scales can actually become more difficult to understand because shortened sentences often lack connecting words that help students understand the relationships between facts. Johnson and Otto (1982) found that making sentences shorter and simpler did not make college biology textbooks easier for high school seniors to understand. So many readability indices may not be applicable to science textbooks.

A major challenge in reading biology texts is the number of discipline-specific words. Shorter words are not necessarily any easier to understand because either the word itself (*e.g.* lek), the scientific use of the word (theory), or the concept behind the word (fitness) will be new to a student with little science background. Therefore, the use of technical words

may be a critical factor in biology textbooks' readability.

Some textbooks introduce new terms often, even if the word is used only once. Other books tend to avoid technical words unless they will be repeated often. In attempting to quantify this variable, I coined my own jargon, *logodiversity*: the measure of the use of specialized vocabulary.

There are potential advantages to high textbook logodiversity. Introducing students to the rich and complex language of biology can facilitate their acceptance into a community of professional biologists and solidify their self-images as biologists. Students who are comfortable with the lexicon of biology will probably make a more professional impression in many communication areas, from interviews to papers to presentations. A broad technical vocabulary can also improve students' future reading comprehension, particularly as they read the primary literature. Similarly, students with a strong command of biology terms might also improve their performance on entrance exams for graduate and professional programs.

On the other hand, a study in general business courses found that when textbooks were less readable, courses had fewer A and B grades, lower average grades, and more students withdrawing from the course (Spinks & Wells, 1993). A related disadvantage to high logodiversity is that the students who are most likely to be challenged by it include people who would increase the diversity of our field. Students who are the first in their families to attend college, socio-economically disadvantaged students, those for whom English is not the primary language, and those with learning differences related to communication are likely to find concepts even more difficult to master when they are confronted with a multitude of new terms. These students also are more likely to believe that they will never belong to the in-group. Certainly faculty can spend extra time teaching the new vocabulary, but this may occur at the cost of instruction in the central concepts of biology.

These concerns led me to ask whether there is much variation in logodiversity among textbooks and whether there were a simple way to quantify it. Being able to ascertain quickly the logodiversity of a textbook before adopting it might lead to more informed textbook choices.

MATERIALS AND METHODS

Using a search engine, I located 100 on-line syllabi of animal behavior courses that listed textbooks in 2004, taken in the order identified. I continued my analysis using the six most common textbooks that had indices. For each word in the glossary, I counted the number of times the word occurred in the index.

I analyzed these data using a modification of the Shannon-Wiener Index of Diversity, which is used to quantify species diversity in natural communities. It is based on both the number of species (richness) and the evenness of the community. In other words, the index is sensitive to whether there are comparable numbers of individuals in each of the species as opposed to there being a few common species and many rare ones. The Shannon-Wiener index of diversity is calculated as:

$$H' = - \sum_{i=1}^s p_i \log_e p_i$$

Where H' = The Shannon-Wiener index of diversity

s = Number of species in a community

p_i = Proportion of the community of i th species.

I adapted this so that:

s = number of words in glossary

p_i = proportion in index of i th word.

and calculated logodiversity as:

$$(s^2/H')/1000$$

The value of the Shannon-Wiener index of diversity increases with both the number of species and the evenness of their proportion in the community. Logodiversity values *increase* with number of specialized words (s) and *decrease* with evenness in word occurrence. Logodiversity values are *lower* when a text uses only those specialized words that are used often. Logodiversity values are *higher* when many specialized words are used, especially if each word is rarely used.

I also analyzed the relationship between the value of the logodiversity index and other measures of logodiversity that were easier to calculate.

RESULTS

Nine textbooks accounted for 89% of the textbooks used in undergraduate animal behavior courses (Fig. 1). Six of the nine most commonly used textbooks identified in the survey had glossaries. Therefore, I continued my analysis on these six.

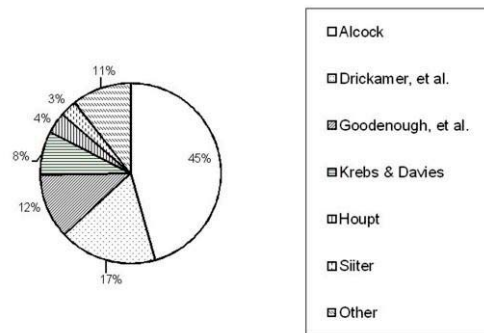


Fig. 1. Use of textbooks in college animal behavior courses (listed in descending order) as found in a survey of online syllabi in 2004.

The books differed greatly in their inclusion of technical terms (Table 1). The total number of words in glossaries ranged from 120 to 375. The logodiversity index values ranged from 3.44 to 29.5, nearly an order of magnitude of difference. A comparison of texts with high and low logodiversity reveals that high logodiversity was due not only to the number of words in the glossary, but also to the large number of words used only once or twice in the high logodiversity example (Fig. 2).

These results indicate that it may be important to examine textbooks for their use of language. However, calculating logodiversity is prohibitively time consuming. Therefore, I tested a variety of other measures to see which would correlate most closely to logodiversity. Two measures that were strongly correlated with the logodiversity score were the total number of words in the glossary (Fig. 3; $R^2 = 0.9772$) and the ratio of pages in the glossary to pages in the body of the text (Fig. 4; $R^2 = 0.9112$). In the latter measure, a textbook with a nonstandard layout (Slater) was an outlier and excluded from the analysis. There was no correlation between logodiversity of a textbook and how many courses were using it ($R^2 = 0.11$).

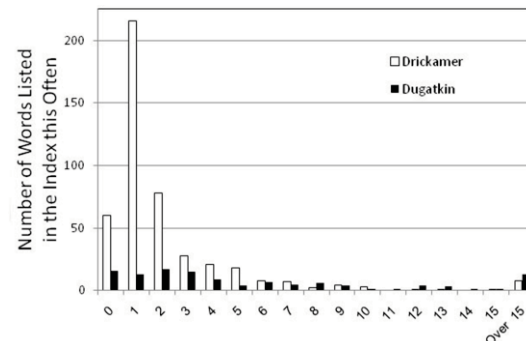


Fig. 2. Evenness of terms used in textbooks with the highest and lowest logodiversity values.

DISCUSSION

When selecting a textbook, biology instructors have many characteristics to evaluate including the book's general approach, topics, pedagogical aids, cost, and artwork. Logodiversity may also be an important factor to consider, though my findings indicate that is not currently a common consideration.

Animal behavior textbooks in this study differed greatly in their use of technical terms. Blystone (1987) contends that some authors use new terms in textbooks "like seasoning to whet the appetite of fellow professionals" to demonstrate that the book reflects current research, and that this practice makes textbooks less effective for student use. Whether one agrees with this view or not, recognizing the level of logodiversity may assist instructors in selecting a book that is consistent with their own goals. Recognizing that the logodiversity of a textbook is not an optimal match for the course or students is a critical first step in providing students with appropriate assistance.

The measures used in this study may not be a perfect reflection of actual use of terms in the books. There may have been differences among authors on their judgment of which words should be included in a glossary. This could have caused me to over- or under-estimate logodiversity. Inclusion of words in

Table 1. Measures of technical vocabulary in six textbooks. Numbers in parentheses reflect words that were defined in the glossary but not listed in the index.

Author(s) & Edition	Number of Words in Glossary	Total Number of Pages	Glossary/Text Page Ratio	Logodiversity Index Score
Alcock 7 th	123 (24)	453	0.0123	3.92
Drickamer <i>et al.</i> 5 th	397 (60)	422	0.0315	29.5
Dugatkin 1 st	100 (16)	675	0.0067	3.44
Maier 1 st	357 (18)	569	0.0364	26.11
Siiter 1 st	146 (90)	392	0.0251	13.81
Slater 1 st	119 (92)	233	0.0571	10.65

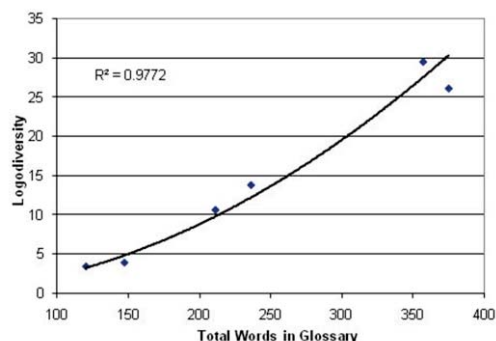


Fig. 3. Correlation between the total number of words in the glossary and the logodiversity for six animal behavior textbooks.

the index is likely to have been automated and therefore less likely to be a source of spurious differences among the textbooks.

Even if the logodiversity index were a perfect measure of the use of technical terms in textbooks, it is not a practical method for evaluating textbooks due to the time required for analysis. However, two other methods yield very similar results. The total number of words in the glossary provides very similar results to the logodiversity index score but still requires some time to measure. A very simple measurement is the ratio of pages in the index to the total number of pages in the body of the textbook (excluding index and glossary). Either of these should be sufficient for most faculty, who will be making decisions based on several criteria and may wish to know merely whether the logodiversity is high, low, or moderate.

IMPLICATIONS FOR TEACHING

The *preparation* of students may result in different optimal textbook logodiversity levels. Some college students are well-versed in the language of biology before arriving at college, while others have had little exposure to any science. Students who are returning to formal education after a long absence may have lost science language skills. The placement of a course in the curricular sequence will also

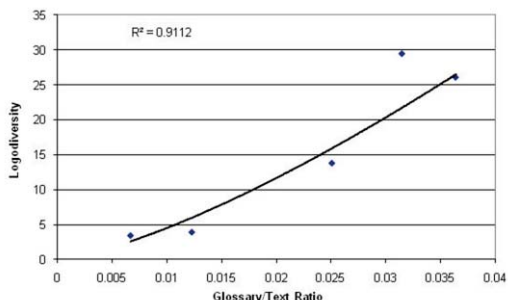


Fig. 4. Correlation between the ratio of pages in the glossary to pages in the text and the logodiversity for five animal behavior textbooks.

influence the level of vocabulary that students can manage. The students may also have difficulties if they are English language learners or have learning differences related to communication.

The *goals* of students may also result in different optimal textbook logodiversity levels. Those planning to attend graduate or professional schools need a more sophisticated science vocabulary in order to transition easily to the next level of their education.

In practice, courses are likely to include students with different goals and levels of preparation. When using a textbook with low logodiversity, using supplemental readings from the primary literature may increase our students' working vocabulary. This allows us to concentrate on smaller sets of words while still giving students a more accessible textbook for the majority of their learning.

Whether we use a textbook with high or low logodiversity, all students benefit from learning strategies for coping with unfamiliar words. If we scaffold their reading, we can expect them to understand more than they would if we merely assigned readings. For example, we might provide vocabulary resources before the reading or teach our students how to use glossaries effectively. We can help them to use context cues and word roots for figuring out the meanings of words on their own. Worksheets and reflection questions can assist students in assessing whether they have understood the concepts and vocabulary or whether they need to review the reading.

FUTURE QUESTIONS

Several questions remain unanswered. For example, does logodiversity capture how students experience readability of textbooks? Do other aspects of textbook design significantly assist or impede our students in their understanding of textbooks? Does increased logodiversity actually lead to greater vocabulary comprehension or provide students with a larger working vocabulary? Does possession of a larger specialized vocabulary increase interest, entrance, or performance in a field?

As we consider the best possible textbooks for our courses, we can easily determine their relative logodiversity. Depending on the needs of our students, we may prefer a higher or lower logodiversity. Identifying this level will help us to determine how we can best assist our students in using the textbook effectively.

ACKNOWLEDGEMENTS

I thank Dawn C. Balistreri for careful and ruthless editing. I also benefitted from the perspectives of those who attended a workshop on this topic at the 2007 ACUBE meeting.

REFERENCES

- ARMBRUSTER, B.B., OSBORN, J.H., AND A.L. DAVISON. 1985. Readability formulas may be dangerous to your textbook. *Educational Leadership* 42(7): 18-20.
- BLYSTONE, R. V. 1987. College introductory biology textbooks: an important communicative tool. *American Biology Teacher* 49(7): 418-25.
- JOHNSON, L.L. AND W. OTTO. 1982. Effect of alterations in prose style on the readability of college texts. *Journal of Educational Research* 75(4): 222-29.
- MONTGOMERY, S. 2004. Of towers, walls, and fields: perspectives on language in science. *Science* 303: 1333-1335.
- SPINKS, N. AND B. WELLS. 1993. Readability: a textbook selection criterion. *Journal of Education for Business* 69(2): 83-88.
- WRIGHT, J. D. AND D. L. SPIEGEL. 1984. How important is textbook readability to biology teachers? *American Biology Teacher* 46(4): 221-25.