Science Vocabulary Load of Selected Secondary Science Textbooks

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It has been argued that many students view science as a collection of facts and terms to be memorized. Robert Yager (1983) analyzed secondary level science textbooks to determine vocabulary load and found that the amount of new vocabulary terms presented in such textbooks is higher than that recommended for junior high and high school foreign language courses. Three textbooks analyzed in that study were re-evaluated, taking into account limitations expressed in the earlier study. The new study also included analysis of an earth science textbook; the first study did not. The re-analysis produced a noticeable reduction in vocabulary load estimates with only one book, Modern Chemistry, still measuring above the recommended level for foreign language courses. It is argued that the amount of vocabulary load presented is still too high and may contribute to the problem of science avoidance by secondary students.

The science textbook all too often forms the backbone of the secondary science classroom (Roth, 1989) -a problem that is illustrated well by Harms and Yager (1981), who found that over 90% of all science teachers use a textbook 95% of the time. Textbook dominance may be related to a heavy focus on science vocabulary and may contribute to the problem of science avoidance by secondary students. Y ager (1983) reported that the number of new vocabulary terms presented in secondary science textbooks is in fact higher than that recommended for junior high and high school foreign language classes. Heavy use of scientific terminology can be an obstacle to reading comprehension since the readability levels of many science textbooks are often higher than the grade levels for which they are targeted (Wrights (1982) Aldridge argues that “most of the achievement of students who do complete the secondary school science courses is measured by how well they acquire information and facts” (Aldridge, 1992, p.2). Such information and facts are often heavily laden with technical vocabulary.

Songer and Linn (1991) point out that if students view science as a collection of facts reported in textbooks, then memorization of these facts would be a logical approach to studying science. This can lead students to prefer memorizing, rather than trying to understand, scientific information. Songer and Linn further point out that this method of studying science can lead to “static beliefs” rather than “dynamic beliefs.” Adherence to static beliefs is associated with negative attitudes toward science and the idea that science is not very relevant.

If a part of the crisis in science education is due to an overload of vocabulary generated in part by an overemphasis on memorization of facts, as Yager (1983) suggests, then efforts to control the amount of science vocabulary that students are required to learn are warranted. Yager repotted vocabulary loads ranging from 2,173 words for a physical science textbook to over 17,130 words for a biology textbook. He stated that his figures could be somewhat high because in determining the number of special words contained in a textbook, no attempt was made to avoid counting words more than once. Because textbooks so often are the focus of the secondary science classroom, it is thus important to get a more accurate measure of just how much science vocabulary is presented to students.

Purpose of the Study

This study is, in part, a replication of Yager’s vocabulary analysis conducted in 1983. It is intended to provide a more accurate measure of vocabulary loads presented in current secondary science textbooks.

Because some of the estimates of the previous study appeared to be high, the process for estimating the number of special science words was modified. This new process was then applied to three of the high school textbooks studied by Yager, plus an earth science textbook that was not included in the first study. The four textbooks used are Biological Science: An Ecological Approach, Modern Chemistry , PSSC Physics, and Earth Science.

The additional textbook was included to expand on the original study by providing an initial measure for middle level earth science, because that study had not analyzed any middle level earth science textbooks.

Method

The first three books analyzed were chosen from the list of books used in the Yager study, and represent one textbook each for biology, chemistry and physics. The chemistry textbook, ***Modern Chemistry,*** is identified by Weiss (1987) as one of the most common science books in use during the mid-1980s. The earth science textbook by Silver-Burdett was the most common earth science textbook used in my district during the time of this study.

As was done in Yager's study, only narrative passages were analyzed, with introductory materials, pictures charts, graphs, figures, questions, problems, glossaries, indices, appendices, and other nonnarmtive text excluded. The number of pages of narration was determined foreachbookby counting all pages with up to 1/2 page of narration as 1/2 page, all pages with more than 1/ page of narration as whole pages, and then adding all of these to produce an estimate of the actual number of pages of narration each book contains. As Yager's method counted all the pages in a textbook, disregarding the amount of narrative, this revised method produced a more accurate estimate of the actual amount of narrative contained in a textbook.

Whereas Yager included words counted from a previous page, and did not consider the frequency of appearance of a given word on a given page, in this study, each science term was counted only once, with plurals and other variations of these terms excluded (e.g., for crystal, crystals, crystallize, only crystal counted). For each book every fifth page of narration was analyzed to reduce the amount of material to be analyzed.

Results

This modified method of estimating vocabulary load produced a noticeable reduction in the vocabulary load estimates as compared to those in the earlier study. Limiting the page count just to pages that contained narration significantly reduced the total pages estimated for each book. Whereas Yager included words counted from a previous page and did not consider the frequency of appearance of a given word on a given page, recording each word or term only once in this study also reduced the vocabulary load estimate.

In this new study, *Modern Chemistry* had the greatest estimate of science terms with 2,950. The *BSCS "Green"* textbook had 1,899 terms; the *PSSC Physics* textbook had *1,538* terms; and *Earth Science* had 992 terms. Except for *Earth Science,* these are considered to be high for secondary level science courses, even though these estimates are far lower than those in Yager's study (see Table 1).

Table 1. ***Textbooks analyzed in the study.***

Text	X terms per page	Projected total terms
PSSC Physics	4.0	1,538
	(10.0)	(7,346.6)
BSCS "Green"	4.69	1,899
	(15.7)	(12,560)
Modem Chemistry	5.75	2,950
	(18.4)	(12,769.6)
Earth Science	4.45	992

'Data in parentheses is from Yager (1983).
this book was not included in the Yager study.

Foreign language courses also focus on vocabulary development, so they can provide a model for comparison with science vocabulary development. Rivers (1975) states that vocabulary for French or Spanish first- and second-year high school courses should be limited *to 1,475* words. *Frenchfor Fluency,* a high school textbook by Valette and Valette (1985), contains about 1,800 new words. Hurd et al. (1981), referred to in Yager (1983), set the number of words to be used for foreign languages at the junior high level at about 1,250 and about 2,500 for high school courses. Brown (1984) reports that the trend in foreign language teaching is toward lessening the amount of vocabulary covered by a particular *The Modern Chemistry* textbook, with an estimate of 2,950 terms, is thus found to present students with more vocabulary than is recommended for equivalent grade level foreign language courses. Vocabulary load estimates for the other three textbooks indicate that they present students with lower amounts of vocabulary, which fall within the ranges recommended for foreign languages. For all four textbooks, the new estimates for vocabulary load are substantially lower than those found by the method used in the first study. The conclusion which was drawn by the first study of science textbook vocabulary loads, that current science textbooks greatly exceed the vocabularyloadsuggestcdforforeignlanguagecourses, must therefore be modified.

Discussion

Knowledge of vocabulary is a key to understanding both spoken and written language (Johnson Pearson 1984). Science can be viewed as having its own language and, as Piercey (1982) states, "'probably the most difficult of all of the languages in the upper-grade curriculum are those of the various sciences." Thus, science vocabulary is important and cannot be ignorer', but an incorrect or misdirected emphasis can impede learning in science and may also lead to an incorrector simplistic understanding of the nature of science. Many secondary science students hold the static belief that science is a fixed body of knowledge to be memorized (Aldridge, 1992; Songer & Linn, 1991). Such a belief may arise because many secondary science teachers themselves hold such beliefs (Duschl, 1990; Groves, 1990). Teachers who see science as a fixed set of facts to learn may believe that having students learn (i.e., memorize) science vocabulary is a valid approach to science teaching (Groves, 1990). Students learn that success in memorizing vocabulary Can lead to success in passing the science course. This further exacerbates the problem of static beliefs and negative attitudes towards science.

Daugs (1984) takes issue with the idea that an emphasis on scientific terms and definitions may contribute to the crisis in science education. He argues that it is incorrect to compare science terms with foreign language vocabulary because students have a language context and vocabulary background into which science terms can be placed. However, this argument misses the point. Many science terms represent concepts or phenomena that are entirely new to students. Also, even common words have meanings that arc different in a scientific context (Marshall and Gilmour, 1990). Such words are often perceived as nonsense words by students as Yager (1984) pointed out in his reply to Daugs' criticism. This is usually not the case with vocabulary encountered in the foreign language classroom where most foreign words relate to English words or phrases already in the students' vocabulary.

Young et al. (1991) suggest that teachers read to their students from the textbook, and that they make use of reading strategy questions which can help students understand that science textbooks require different reading Strategies than those they have learned to use with fiction. Memory and Uhlhom (1991) argue for the use ofmultiple textbooks at different readability levels. This would provide weaker readers with materials more suitable to their capabilities Collette and Chiappetta (1994) recommend vocabulary guides be given to students which show how terms are pronounced and provide room for definitions. When designing these guides, teachers should choose the most important terms that the students need to know. However, teachers must be sensitive to distinguish which terms are truly important and not just choose those terms identified in bold print or italics by the textbook itself as being important Thus, a problem with this ad vice is that they do not question the appro priateness of the vocabulary levels. A way to determine the proper number of terms to present per lesson could be modeled on common recommendations for the ideal number of concepts to be presented in a lesson. Henson (1993, p. 67) wrote that daily lesson plans should contain only four or five major ideas. Since many scientific terms represent major concepts or ideas (e.g., evolution, thermodynamics, photosynthesis), teachers could limit the number of new terms presented per lesson to only those few terms which are required to accomplish lesson objectives. Answering the question "What do the students really need to know?" may help teachers sort between important and unimportant terms. A drawback to these last two suggestions is that they can result in a large amount of variation in lesson content from one teacher to the next.

Many science terms found in these four textbooks could be omitted or replaced by nonscientific words, with which students are mote familiar. Memorizing vocabulary in science classrooms could also be viewed more realistically as one among many teaching techniques that provide a greater focus on central themes, issues, and concepts of science. Such changes in use of science vocabulary would be more in line with current science reform efforts being conducted by the AAAS, NAS, and NSTA, and with the various constructivist approaches to science teaching that are presently being advocated (Shymansky & Kyle, 1992; O'Loughlin, 1992). Methods of vocabulary instruction that are in accordance with current approaches to science education are available (Thelen, 1984; Manzo and Manzo, 1990, Ogle, 1986; Piercey, 1982).

These changes have not occured possibly because textbook narration may not have changed very much in terms of vocabulary load. Lynch and Strube (1983) found that the formal language found in textbooks has scarcely changed in over 100 years, Historically, education has focused heavily on memorization and recitation which, in the science class, has led to a heavier emphasis onmemorizing science terms than on learning science concepts and direct experience. This older form of science teaching, despite continued efforts of educators to direct science teaching toward a more experiential and concept-oriented mode, continues today (Stake & Easley, 1978; Weiss, 1978; Harms & Yager, 1981; Duschl, 1990: Tobias 1990). and most likely will not end until the orientation of the science teacher-and textbook writers-becomes more positive, in practice, toward more concept-oriented and activity-oriented forms of science education.

Conclusions

Although vocabulary loads for science textbooks are not as high as earlier estimates indicated they still show a heavy emphasis on terminology. Focusing on memorization may contribute to the development of misconceptions among students that science is a finished body of knowledge, comprising facts, proofs, and absolutes to be absorbed. This misinterpretation of the nature of science has been addressed many times (Polanyi, 1958; Nash, 1963; Kuhn, 1962; Giere 1988; Duschl, 1990). Many students may not perceive science teaching focused on rote memorization of terminology as meaningful to their lives. By reducing the emphasis on rote memorization of vocabulary and on vocabulary study as an end in itself and focusing instead on the use of vocabulary as simply a means of guiding students towards the attainment of science concepts, the current problem with excessive vocabulary load may be corrected.

References

Aldridge, B.G. (1989). Essential changes in secondary science: Scope, sequence, and coordination. In M.K. Pearsall (Ed.), *Scope, sequence, and coordination Vol. II: Relevant research* (pp. l-7). Washington, DC: National Science Teachers Association.

Biological Science Curriculum Study (BSCS). (1982). *Biological science: An ecological approach.* Boston, MA: Houghton-Mifflin,

Brown, C. (1984). The challenge for excellence in curriculum and materials development. In G.A. Jarvis *(Ed.), The challenge for excellence in foreign language education.* The Northeast Conference on the Teaching of Foreign Languages.

Brown, F., Martin, H., & Kemper, G. (1982). *Earth science.* Morristown, NJ: Silver-B&et&

Daugs, D.R. (1984). Comments on 'the importance of terminology in teaching K- 12 science.' *Journal of Research in Science Teaching, 21,957-959.*

Duschl, R.A. (1990). Restructuring science education: *The importance of theories and their development.* New York: Teachers College Press.

Giere R.N. (1988). Explaining science: *A cognitive approach.* Chicago: University of Chicago Press.

Groves, F.H. (1990). A qualitative study of the beliefs and professional backgrounds of secondary level science teachers in a public school and a Protestant christian school in Colorado (Doctoral disertation, University of Colorado at Boulder, 1990). *Dissertation Abstracts Intern ,_"., ' n d. /4 0032836.*

Haber-Schaim U. Cross J.B. Dodge, J H . & Walter, J.A. (1971). *PSSC physics.* Lexington, MA: DC Heath & Co.

Harms, N.C.,& Yager, RE. (1981). *What research says to the science teacher,* Vol. 3. (Report No. 47 1 14776). Washington, DC: National Science Teachers Association.

Henson,K. T. (1993).Methods *and strategies for teaching in secondary and middle schools (2nd ed.).* New York: Longman.

Hurd, P.D., Robinson, J.T., McConnell, M.C., & Ross, N.MJr., (1981). *The status of middle and junior high school science, Volume I and summary report.* Louisville, CO: Center for Educational Research and Evaluation, BSCS.

Hurd, P.D., Robin, J.T., McConnell, M.C., & Ross, N.M., Jr. (198 1). *The status of middle andjunior high school science, Volume II technical report.* Louisville, CO: Center for Educational Research and Evaluation, BSCS.

Johnson, D. D., &Pearson, P.D. (1984). *Teaching reading vocabulary* (2nd ed.). Ft. Worth: Holt, Rinehart and Witton.

Kuhn, T.S. (1962). *The structure of scientific revolutions. Chicago:* University of Chicago Press.

Lynch, P.P., & Strube, P. (1983). Tracing the origins and development of the modem science text: Are new textbooks really new? *The Awtralian Science Teachers Journal, 29(3), 27-36.*

Marshall, S. & Gihnour, M. (1990). Problematical words and concepts in physics education: A study of Papua New Guinean students' comprehension of non-technicalwords used in science. Physics Education, 25,330-337.

Manzo, A., & Manzo, U. (1990). Content urea reading: A heuristic approach. Columbus: Merrill.

Memory, D.M. & Uhlhom, K.W. (1991). Multiple textbooks at different readability levels in the science classroom. *School Science and Mathematics,* *91*, 64-72.

Metcalfe, H.E., Williams, J.E., & Castka, J.F. (1982). *Modern chemistry*. New York: Holt, Rinehart & Winston.

Nash, L.K. (1963). *The nature of the natural sciences*. Boston: Little, Brown and Company.

Ogle, D.M. (1986). K-W-L: A teaching model that develops active reading of expository text. *The Reading Teacher, 39*, 564-570.

O'Loughlin, M. (1992). Rethinking science education: Beyond piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of Research in Science Teaching, 29*, 791-820.

Piercey, D. (1982). *Reading activities in content areas: An idea-book for middle and secondary schools* (2nd ed.). Boston: Allyn and Bacon.

Polanyi, M. (1958). *Personal knowledge*. Chicago: University of Chicago Press.

Rivers, W.M. (1975). *A practical guide to the teaching of French*. New York: Oxford University Press.

Roth, K. J. (1992). Science education: It's not enough to 'do' or 'relate'. In M.K. Pearsall (Ed.), *Scope, sequence, and coordination of secondary school science vol. II: Relevant research* (pp.151-164). Washington, DC: National Science Teachers Association.

Shymansky, J.A., & Kyle, W.C., Jr. (1992). Establishing a research agenda: Critical issues of science curriculum reform. *Journal of Research in Science Teaching, 29*, 749-778.

Songer, N.B., & Linn, M.C. (1991). How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching, 28*, 761-784.

Stake , R.E., & Easley, J. (1978). *Case studies in science education, volume I and II*. (U.S. Government Printing Office, Stock No. 038-000-00376). Washington, DC: University of Illinois at Urbana-Champaign.

Thelen, J. N. (1984). *Improving reading in science*. Newark: International Reading Association.

Tobias, S. (1990). *They're not dumb; they're different*. Tucson, AZ: Research Corporation.

Valette, J.P., & Valette, R.M. (1985). *French for fluency*. Lexington, MA: D.C. Heath and Company.

Weiss, I.R. (1987). Report of the 1985-86 national survey of science and mathematics education. Washington, DC: Center for Educational Studies, Durham, North Carolina.

Weiss, I.R. (1978). Report to the 1977 national survey of science, mathematics, and social studies education. (U.S. Government Printing Office, Stock No. 038-000-000364) Washington, DC: Center for Educational Research and Evaluation, Research Triangle Park, North Carolina.

Wright, J.D. (1982). The effect of reduced readability text materials on comprehension and biology achievement. *Science Education, 66*, 3-13.

Yager, R.E. (1983). The importance of terminology in teaching K-12 science. *Journal of Research in Science Teaching, 20*, 577-588.

Yager, R.E. (1984). Author's response. *Journal of Research in Science Teaching, 21*, 959-960.

Young, P., Ruck, C., & Crocker, B. (1991). Reading: It's not quite Jack in the Beanstalk. *The Science Teacher, 58*, 46-49.

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