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# Comprehensible Textbooks in Science for the Nonnative English-Speaker: Evidence from Discourse Analysis

**This paper develops practical applications of the author's 1983 work, which used discourse analysis to compare textbooks providing practical scientific knowledge for ninth grade general science. The author collected data on the reading comprehension of 72 subjects (30 nonnative and 42 native English-speaking students) on the same passages. Her research considered readability of textbooks on three planes: (1) usage, (2) use, and (3) interaction. The main implication derived from the study is that both nonnative and native English readers will greatly benefit from instructional materials and teaching strategies that provide multiple access to science information. This supports the research findings of Cummins (1981, 1982), Krashen (1981,1982), Widdowson (1978, 1979), Long (1982, 1985) and Long and Sati (1983) on sheltering (contextualizing), higher level questioning, authentic language, and interaction for second language acquisition. Implications for textbook writers and selectors and content area and ESL teachers are given, along with suggestions for sheltering the English of science textbooks.**

This paper may be of interest to both high school educators, especially those involved in reading for content areas, and linguistic researchers. It begins by providing definitions and background in the field of discourse analysis in relation to scientific texts. The major portion of the paper then describes research conducted by the author on the kinds of discourse employed in science textbooks for secondary school students. The paper concludes with some discussion of practical implications of this work and some suggestions for sheltering the English of science for textbook writers, textbook selectors, and teachers of both English as a second language and the content areas.

The main implication derived from the study is that both nonnative and native English readers will greatly benefit from instructional materials and teaching strategies that provide multiple access to science information. Science textbooks achieve greater comprehensibility through instructional verbal text (words, sentences, paragraphs), through explicative iconic text (drawings, photos, tables), and through the kinds of questions that stimulate high levels of student-textbook interaction.

The two passages below are taken from textbooks used in ninth grade science classes in a California high school where students were both native and nonnative readers of English. Passage A was taken from the academic class textbook *Everyday Problems in Science* (Hurd & Mayfield, 1972). Passage V was taken from the vocational class textbook for non-college-bound students *Concepts and Challenges in Life Science* (Bernstein, Schachter, Winkler, & Wolfe, 1979).

### Passage A

The inner defenses of our bodies include two main groups of germ fighters. One group is made up of white blood cells. You have already learned that some of these wrap themselves around and destroy germs. When germs get inside the body where they can grow and reproduce, the white cells usually attack them almost at once. Since white blood cells are in blood and lymph, they are carried to every part of the body. Some stay in one place and attack any germs that come near. Others travel to the place where the germs are and then attack them. Sometimes, instead of destroying germs, the white cells form a wall around them. This often happens when tuberculosis germs get into the lungs. The wall keeps the germs and their toxins from spreading. In time, this wall becomes thick and hard.

If germs that get inside are not destroyed quickly, the body usually speeds up its making of white cells. An increase of white cells is nearly always a symptom of an infection in some part of the body. Doctors consider this symptom when they make a diagnosis. To find if the white cells have been increased, a small amount of blood is drawn from the body and examined through a microscope. The white cells in a certain volume of blood are counted. In a severe infection, the count may show two or three times as many white cells as usual.

### Passage V

White blood cells. Some germs enter the body by getting past the defenses of the skin and the respiratory organs. When this happens, the body's second line of defense goes to work. The white blood cells are the second line of defense. White blood cells travel through the blood in search of bacteria. The white cells can even squeeze through the walls of the capillaries. Outside the blood vessels, they surround bacteria. They destroy the bacteria by digesting them.

How do white blood cells help protect the body?

These two passages treat similar topics at similar readability levels, but they differ in important ways. To explore these differences, the research reported here used discourse analysis of the passages, as well as cloze tests of students and recall interviews. I will begin by defining terminology used in discourse analysis and in the discussion of the contexts of use for science.



## Definitions

*Discourse* refers to language use, that is the communicative function of language. *Discourse analysis* is defined here as the investigation of the way sentences are put to communicative use (Widdowson, 1979a, pp. 92-93). In functional terms *scientific discourse* is a set of rhetorical (illocutionary) acts, such as defining, classifying, and exemplifying. Thus, *discourse analysis of texts* in Widdowson's sense is the investigation of the formal properties of a piece of language beyond the limts of a sentence.

If Widdowson's (1979a) definition of scientific discourse as "a set of rhetorical acts" (p. 16) is accepted, then there is clearly a need to consider approaches to text analysis that go beyond traditional approaches to what makes textbooks difficult or easy. For example, there is more to determining reading ease than readability formulae, which are nearly always based on grammatical and lexical properties of texts alone, not on discourse properties. And, while it has been shown that scientific English contains certain categories of *usage*, such as frequent passives, long nominal groups, and relative clauses (Strevens, 1980; Master, 1982), an emerging line of research focuses on the notion of *use*, the communicative function of the language of science.

Instead of analyzing science texts as examples of scientific English usage, I chose to examine discourse—the communicative functions of language, such as generalization, qualification, explanation. I focused the discourse analysis on the coherence relationships between illocutions (the communicative acts that sentences are used to perform, such as the functions listed above). *Coherence* is "the link between" these communicative acts (Widdowson, 1979a, p. 87).

I also saw a need to analyze the interactive negotiation of meanings and the structures of communication an author uses to convey information to the reader. This interactive relation concerns such acts as initiation, response, and elicitation. Thus, the discourse analysis of the science texts discussed here goes beyond readability formulae in determining what makes a text easy or difficult to read and beyond specific features of scientific English usage in determining what constitutes the special register of science. The study examines the effectiveness of the communication between author and reader along three planes of discourse—usage, use, and interaction—each of which is discussed in more detail below.

## Background

In the mid- to late 1970s the field of English for Science and Technology (EST) was a major area of linguistic research at the university level. Selinker, Trimble and Trimble (1975), for example, published their Rhetorical Process Chart to show how the language of science coveyed information on several rhetorical levels.

**Table 1**

## Rhetorical Process Chart
## English for Science and Technology (EST)*

**Level** **Description**

A Objectives of the total discourse.
Examples: 1. Detailing an experiment
2. Making a recommendation
3. Presenting new hypotheses, theories
4. Presenting other ESL information

B General rhetorical functions employed to develop the objectives of Level A
Examples: 1. Stating purpose
2. Reporting past research
3. Discussing theory
4. Stating the problem
5. Presenting information on apparatus: Description
6. Presenting information on apparatus: Operation
7. Presenting information on experimental procedures
8. Referencing an illustration
9. Relating an illustration to the discussion

C Specific rhetorical functions employed to develop the general functions of Level B
Examples: 1. Definition
2. Classification
3. Description: physical, function
4. Description: process

D Rhetorical techniques that provide relationships within and between the units of Level C
Examples: 1. Time order 5. Comparison
2. Space order 6. Contrast
3. Causality 7. Analogy
4. Result 8. Exemplification

*This is a revised version of the rhetorical section of the Rhetorical Grammatical Process Chart (Lackstrom, Selinker and Trimble, 1975)



Such research implied that teachers of university courses for nonnative English speakers could teach specific aspects of the language pertinent to their courses—aspects of English for science, for example, or more specifically, English for engineers.

At the same time Widdowson (1979a) proposed ideas about the language of science that went beyond identifying specific vocabulary items or grammatical constructions (e.g., heavy noun compounds, passive voice verbs). He claimed that the language of science can be viewed as a specific cultural type. For Widdowson, reading in science is reading an international language which employs particular rhetorical processes, including definitions, exemplifications, and generalization. In whatever language of the world, the scientific method has followed similar stages of development and the literature of science world-wide has identifiable rhetorical features. Thus, learning what these features are might be very useful to students who must read and write in this field.

While this kind of thinking was evidenced in the EST literature, research on discourse—the analysis of the rhetorical forms used in expository texts, for example—began to provide detailed insight into the complexity of exposition. Meyer (1975) and Kintsch and van Dijk (1978) conducted discourse analysis research on various rhetorical processes involved in reading expository texts. They found specific types of idea units—propositions—and began to outline the rhetorical structure of the content of the texts they investigated. Meyer (1975) classified rhetorical predicates in 18 ways, an example of which is the *alternative rhetorical predicate,* in which equally weighted options are given. One of her sample sentences—*Recovery is slowed down or halted*—appears in a content structure tree diagram with *slowed down* and *halted* on the same level of content structure, related to each other by the *alternative* rhetorical predicate *or.* Kintsch and van Dijk (1978) analyzed one of their sample texts—*A series of violent, bloody encounters between police and Black Panther Party members punctuated the early summer days of 1969*—into seven propositions beginning with *series, encounter* and ending with *time: in, summer, 1969.* This propositional research provides detailed insights into the complexity of expository texts.

These types of research—on EST and on the propositional structure of expository texts—stimulated the research discussed in this article.

### Study of Science Texts and Students

Prior to the early 1980s the literature consisted primarily of research on EST and propositional analyses of texts at the university level, mostly with native English speakers. My 1983 study of high school science textbooks broke new ground both by analyzing the discourse of high school science textbooks and by collecting data on both native and nonnative English-speaking students in science classes using these texts. I took a detailed look at the discourse and interactive features of science materials written for native English speakers and used with both native and nonnative English speakers. My research also posed the question of what simplification for reading in science means.

I compared the textbooks providing practical scientific knowledge for ninth grade general science in two programs: vocational preparation (assumed noncollege-bound) and academic (college) preparation. I also collected data on the reading comprehension of 72 subjects (42 native and 30 nonnative English-speaking students) of the same passages. Typically, at this level native English-speaking (NE) and nonnative English speaking (NN) students are enrolled in the same science classes. Usually, however, higher numbers of NNs are enrolled in the vocational program classes. The unstated assumption is that the "simpler" textbooks used in these classes are more easily mastered by limited English proficient students. This assumption of simplicity formed the basis for three questions:

1. Is the vocational text really simpler than the academic text? Is it more instructive?

2. How do NEs and NNs compare in reading comprehension measures based on such textbooks?

3. What is the relationship of text features to reading comprehension for NE and NN students?

I analyzed passages of 800 to 1200 words on the same topics (the skeleton and the body's defenses against germs) in both textbooks, looking at three planes of discourse with which the readers of both science texts must deal.

### Plane 1: Usage

*Usage* includes surface forms identified by traditional readability formulae, the vocabulary and grammatical complexity of the material. Both the Flesch Formula (1948) and the Fry Graph (1968) were used to show by syllable count and average sentence length the grade level readability of each passage. In addition, the authors' or editors' stated reading level of each textbook and a clause complexity index (Cook, 1979) provided information on the difficulty level of the texts.

### Plane 2: Use

*Use* relates to the coherence of the text as a series of illocutionary acts, or rhetorical functions—the writer's attempt to convey a particular meaning to the reader by means of language organized into discourse. An investigation of language use shows information is conveyed to the reader through rhetorical devices such as definitions, generalization, and additive informatives; and how the paragraphs convey information deductively, inductively, or in a balanced way. Table 2 presents an outline of the discourse members found in these science texts. A *member* is a sentence, question, title, subtitle, caption, or label appearing in the verbal text of the passage. When classified according to



their functions in the discourse, members of the passages fall into three basic categories: focusing, instructing, and glossing.

**Table 2**

## Discourse Members

| | |
|---|---|
| Focusing: | Focusing statement |
| | Question |
| | Subtitle/label |
| | Section focus/title |
| Instructing: | Recall |
| | Reiteration |
| | Particularization |
| | Informative |
| | Generalized informative |
| | Additive informative |
| | Substantiating informative |
| | Restricted informative |
| | Contrastive informative |
| | Evaluative informative |
| | Hypothetical informative |
| | Corrective informative |
| Glossing: | Restatement |
| | Pointer |
| | Directive |
| | Comment |
| | Aside |

Rather than attempt to describe the full 50 pages of analysis of discourse functions of members in the texts, I have provided a representative sample paragraph from the academic program text in Table 3.

**Table 3**

## Sample Analysis of Text

Passage A1
Paragraph 2
(Deductive: generalization—examples)
(Description)

| Member | Discourse function |
|---|---|
| a. Your skeleton forms the framework of bones that supports the rest of your body. | Focusing statement<br>Generalized informative |

b. Some of the bones, such as the skull and the ribs, protect delicate organs inside your body. — Restricted informative

c. You could not move about as you do if you had no bones to act as levels. — Additive informative

d. Your skeleton is rigid enough to hold your body in shape, yet joints between the bones allow them to move. — Contrastive informative

e. There are more than 200 bones in the human body. — Additive informative and end of paragraph informatives

f. The pictures on page 146 show the main parts of the skeleton. — Pointer (implied) and end of paragraph

Paragraph 2 from passage A1 is a deductive description which leads from a generalization to examples. Its members are defined as:

*focusing statement*: a declarative introduction to a new concept, usually following a paragraph boundary;

*generalized informative*: a declarative that presents the general concepts talked about in adjacent discourse;

*restrictive informative*: a declarative with some form of limiting words on the concept;

*contrastive informative*: a declarative which provides an opposing idea; and

*pointer*: a glossing member which directs the reader to nonlinear information in pictures and charts.

As can be seen in the discourse member list and the sample paragraph, the detailed discourse analysis focused on the illocutionary functions of the passages. The discourse of the academic passages contains a higher percentage of instructing functions than does the discourse of the vocational passages. Table 4 presents Plane 2, the paragraph types and member discourse functions, for the academic passages (A1, A2) and the vocational passages (V1, V2) in relation to Planes 1 and 3.



Table 4

## Internal Text Analysis Summary

| | | | Text passage | A1 | A2 | V1 | V2 |
|---|---|---|---|---|---|---|---|
| READING EASE | VERBAL TEXT | | Author's/Editor's description | for average 9th grader | | 4th-5th grade | |
| READING EASE | VERBAL TEXT | BODY COPY | Readability: Fry Average<br>Fry Average<br>Fry 100-word<br>Flesch average<br>Flesch 100-word | <br>6th<br>6th<br>6th<br>6th | <br><br>4th<br><br>6th | <br>4th<br>4th<br>6th<br>6th | <br><br>8th<br><br>8-9th |
| READING EASE | VERBAL TEXT | BODY COPY | Style complexity | simple | medium | simple | simple |
| DISCOURSE | VERBAL TEXT | BODY COPY | Paragraph types:<br>Logic<br>Illocutionary function (% instructive) | <br>deductive<br>77% | <br>balanced<br>82% | <br>deductive<br>63% | <br>other<br>64% |
| DISCOURSE | | | Member discourse functions:<br>Focusing<br>Instructing<br>Glossing | <br>40%<br>52%<br>8% | <br>32%<br>65%<br>3% | <br>27%<br>53%<br>20% | <br>49%<br>34%<br>17% |
| OTHER TEXT FEATURES | ICONIC TEXT | LAYOUT | Typographics:<br>Access functions<br>Rhetorical functions<br>Macropunctuation | <br>Roughly Equivalent<br>Roughly Equivalent<br>Long Information Flow | | <br><br><br>Short Information Flow | |
| OTHER TEXT FEATURES | ICONIC TEXT | LAYOUT | Illustrations:<br>Motivational<br>Explicative/ retentional | <br>8%<br>92% | <br><br>100% | <br>20%<br>80% | <br>33%<br>67% |
| OTHER TEXT FEATURES | QUESTION | OTHER | Question types:<br>Above factual level | <br>34% | <br>45% | <br>11% | <br>25% |

## Plane 3: Interaction

Plane 3 focuses on the various acts the author uses to involve the reader. Of particular interest is the use of illustrations and questions for instructional support. Illustrations are classified as:

*motivational*: to get the reader's attention;

*explicative*: to explain an idea that is not clearly expressed by words; and

*retentional*: to increase the memorability and retentional value of the prose to which the illustration is related.

As Table 4 shows the academic passages (A1, A2) employ more information-carrying illustrations than the vocational passages do. These provide the reader more contextual clues to facilitate comprehension of the verbal text. Interaction of reader and text is also affected by the types of questions for the passage, ranging from factual—requiring verbatim recall—through a Bloom's Taxonomy of question types above the factual level. As Table 4 shows, the percentage of questions above the factual level in the academic text runs from over a third to nearly half of the questions, while in the vocational passages only a tenth to a quarter of the questions are above the factual-recall level. The difference in the quality of questions relates to the quality of information the student thinks about while reading and answering questions. The interaction of reader and text is affected by authors' and editors' choices of illustrations and questions.

The detailed analysis of these science texts shows that the assumption of simplicity, or reading ease, of the vocational text is at least questionable. While the authors and editors judge the vocational text to be easier than the academic one, the readability formulae and style complexity indices disagree. The issue of the relationship of text features to reading comprehension is more complex than indicated by readability formulae or clause complexity (Plane 1). It involves not only overall reading ease but also discourse relationships and other text features. For high school science textbooks, the relationship of text features to reading comprehension concerns not merely word and sentence length (Plane 1), but the ways all the information on the page is conveyed to the reader. An analysis of textbook discourse (Plane 2) and interaction (Plane 3) shows that science textbook discourse involves rhetorical functions in the verbal text as well as interaction through illustrations and question types.

By paragraph type and discourse function, the academic passages devote a higher percentage of verbal text to instruction than do the vocational passages. A higher percentage of illustrations in the academic passages is instructional. Finally, compared to the vocational text the academic text contains a higher percentage of questions above the factual level. These results indicate that:



(1) The academic text may be as easy to read as the vocational text because the discourse functions engage the reader instructionally. The illustrations and questions support the instructional role of the verbal text.

(2) The vocational text may discourage the reader from gaining as much information on a topic as the academic text provides because the vocational text uses less explicative verbal text and fewer informational illustrations to support the reader. If the purpose of content area reading is to gain information, then the text needs to provide multiple means for the reader to gather that information, means that involve all three planes of discourse.

In addition to the analysis of science texts, exploratory data were collected from readers of these texts.[2] Many dimensions of reading comprehension were measured. NE and NN student performance with these texts was analyzed through classroom observation, cloze testing, free and cued recalls, and subjective comments from students. The results of the cloze testing (Tables 5 and 6), recalls, and subjective comments of seven students support the tentative conclusions of the text analyses.

**[See Tables 5 and 6]**

## Conclusions and Further Questions

(1) The complex relationship of text features to reading comprehension involves all three planes of discourse and cannot adequately be judged by readability formulae, which assess only Plane 1 features.

(2) It is questionable whether the vocational text is necessarily simpler than the academic text, particularly when positive redundancy factors (e.g., illustrations, exemplifications) are considered. The longer text may provide more opportunity to understand the science concepts, to acquire the "science culture." A two-paragraph explanation of the action of white blood cells, with examples of diseases and infections and a graphic illustration may actually make the reading less difficult to comprehend than a shorter one-paragraph version with no space devoted to examples or clear illustration of the concept.

(3)The academic text is not necessarily more difficult. The cloze showed that the academic and vocational students performed similarly on three of the four passages (A1, V1, and V2), whether the cloze passage was from the academic or vocational textbook. On the fourth passage (A2), the nonnative speakers scored higher than the native English speakers. Furthermore, the NNs scored higher than the NE vocational students on all passages. Does this mean that reading comprehension of NNs compares favorably to that of NEs on both texts? That is, once the NNs have been judged fluent enough in English to succeed in an English-only curriculum, is there reason to believe that they can benefit from the same types of material as do the native English speakers?

## Table 5
## Performance of Subjects on Cloze Tests Scored by Exact-Replacement Method

| Test Form | Class | NEs N | NEs M | NEs SD | NNs N | NNs M | NNs SD | Total* N | Total* M | Total* SD |
|---|---|---|---|---|---|---|---|---|---|---|
| A1 | Ac. | 18 | 15.83 | 2.24 | 4 | 15.25 | 3.77 | 22 | 15.73 | 2.60 |
| | Voc. | 12 | 10.83 | 4.88 | 9 | 12.00 | 2.58 | 21 | 11.33 | 4.10 |
| | Ex. | 5 | 16.00 | 2.61 | 6 | 13.00 | 1.53 | 11 | 14.36 | 2.57 |
| | ESL | | | | 6 | 9.00 | 2.58 | 6 | 9.00 | 2.58 |
| | | | | | | | | T3 | 19.00 | 3.56 |
| | Total | 35 | 14.14 | 4.18 | 25 | 12.04 | 3.30 | | | |
| V1 | Ac. | 18 | 14.89 | 2.83 | 4 | 15.50 | 4.56 | 22 | 15.00 | 3.22 |
| | Voc. | 12 | 9.92 | 4.87 | 9 | 12.44 | 3.30 | 21 | 11.00 | 4.45 |
| | Ex. | 5 | 15.60 | 3.01 | 6 | 12.17 | 3.53 | 11 | 13.83 | 3.72 |
| | ESL | | | | 6 | 8.83 | 3.93 | 6 | 8.83 | 3.93 |
| | | | | | | | | T3 | 22.00 | 3.56 |
| | Total | 35 | 13.29 | 4.42 | 25 | 12.00 | 4.29 | | | |
| A2 | Ac. | 13 | 12.00 | 2.35 | 6 | 13.17 | 2.91 | 19 | 12.37 | 2.60 |
| | Voc. | 14 | 8.07 | 4.11 | 11 | 9.36 | 4.56 | 25 | 8.64 | 4.36 |
| | Ex. | | | | | | | | | |
| | ESL | | | | 6 | 8.00 | 3.42 | 6 | 8.00 | 3.42 |
| | | | | | | | | T3 | 20.00 | .82 |
| | Total | 27 | 9.96 | 3.91 | 23 | 10.00 | 4.36 | | | |
| V2 | Ac. | 13 | 14.54 | 2.24 | 6 | 15.00 | 3.37 | 19 | 14.68 | 2.66 |
| | Voc. | 14 | 9.93 | 4.30 | 11 | 10.91 | 3.87 | 25 | 10.36 | 4.15 |
| | Ex. | | | | | | | | | |
| | ESL | | | | 6 | 8.67 | 2.21 | 6 | 8.67 | 2.21 |
| | | | | | | | | T3 | 17.33 | 1.25 |
| | Total | 27 | 12.15 | 4.16 | 23 | 11.39 | 4.10 | | | |

NEs = Native English-speaking students.
NNs = Nonnative English-speaking students.
A1, A2 = academic textbook passages; V1, V2 = vocational.
Types of classes are academic (Ac.), vocational (Voc.), an extra science class (Ex.), and ESL.
*Totals for students can be read vertically or horizontally.
Data on 3 teachers (T3) is added in column 5 only.



## Table 6
## Performance of Subjects on Cloze Tests Scored by Contextually-Acceptable Replacement Method

| Test Form | Class | NEs N | NEs M | NEs SD | NNs N | NNs M | NNs SD | Total* N | Total* M | Total* SD |
|---|---|---|---|---|---|---|---|---|---|---|
| A1 | Ac. | 18 | 21.39 | 2.59 | 4 | 20.50 | 4.50 | 22 | 21.23 | 3.04 |
| | Voc. | 12 | 14.25 | 6.10 | 9 | 17.11 | 3.54 | 21 | 15.48 | 5.35 |
| | Ex. | 5 | 21.00 | 2.37 | 6 | 18.00 | 1.91 | 11 | 19.36 | 2.60 |
| | ESL | | | | 6 | 13.17 | 3.24 | 6 | 13.17 | 3.24 |
| | | | | | | | | T3 | 26.00 | 1.41 |
| | Total | 35 | 18.86 | 5.31 | 25 | 16.92 | 4.11 | | | |
| V1 | Ac. | 18 | 20.56 | 3.93 | 4 | 20.50 | 5.68 | 22 | 20.55 | 4.30 |
| | Voc. | 12 | 14.33 | 6.65 | 9 | 18.11 | 4.12 | 21 | 15.95 | 6.00 |
| | Ex. | 5 | 21.40 | 2.42 | 6 | 15.50 | 3.45 | 11 | 18.18 | 4.22 |
| | ESL | | | | 6 | 12.33 | 4.11 | 6 | 12.33 | 4.11 |
| | | | | | | | | T3 | 27.00 | .82 |
| | Total | 35 | 18.54 | 5.77 | 25 | 16.48 | 5.11 | | | |
| A2 | Ac. | 13 | 17.54 | 2.41 | 6 | 19.33 | 5.47 | 19 | 18.11 | 3.75 |
| | Voc. | 14 | 12.07 | 5.92 | 11 | 13.45 | 5.81 | 25 | 12.68 | 5.91 |
| | Ex. | | | | | | | | | |
| | ESL | | | | 6 | 10.67 | 3.90 | 6 | 10.67 | 3.90 |
| | | | | | | | | T3 | 25.00 | 1.63 |
| | Total | 27 | 14.70 | 5.33 | 23 | 14.26 | 6.19 | | | |
| V2 | Ac. | 13 | 20.77 | 3.60 | 6 | 21.17 | 4.06 | 19 | 20.89 | 3.75 |
| | Voc. | 14 | 14.57 | 5.77 | 11 | 16.27 | 5.74 | 25 | 15.32 | 5.82 |
| | Ex. | | | | | | | | | |
| | ESL | | | | 6 | 11.50 | 3.04 | 6 | 11.50 | 3.04 |
| | | | | | | | | T3 | 25.33 | 1.25 |
| | Total | 27 | 17.56 | 5.75 | 23 | 16.30 | 5.89 | | | |

NEs = Native English-speaking students.
NNs = Nonnative English-speaking students.
A1, A2 = academic textbook passages; V1, V2 = vocational.
Types of classes are academic (Ac.), vocational (Voc.), an extra science class (Ex.), and ESL.
*Totals for students can be read vertically or horizontally.
Data on 3 teachers (T3) is added in column 5 only.

In order to determine the reading level of a text, rather than asking how complex the syntax of the text is as measured by readability formulae, we need to ask whether the material provides multiple access to the required information.

In Cummins' (1981, 1982) terms is the material cognitively undemanding (easy) or cognitively demanding (difficult)? Is the material context embedded (with all sorts of extra clues) or is it context reduced (with few clues)? How do we deal with material in the cognitive academic language proficiency (CALP) arena? How can it be sheltered?

In Krashen's (1981, 1982) terms is the material providing *i+1* comphensible input? Does the material provide the student a means to acquire knowledge because the input (*i*) is one increment (*+1*) above the present state of knowledge? Students in content area classes need to be able to apply increasingly higher levels of Bloom's Taxonomy (factual knowledge, comprehension, application, analysis, synthesis, evaluation) to language in use.

Widdowson's (1978, 1979a, 1979b) concerns about authentic language and simplification are also worth considering. Often students are trained to develop reading skills with artificial or overly simplified texts. Is the material used to develop increasingly higher level skills representative of what the students must face outside the language or reading classroom? Are "simple" skills integrated into an organic, authentic whole? Does simplification of form necessarily mean easier text? Instead of restricting the amount of language to which the student is exposed, how do we focus the learner's attention on that language, keep the learner on the instructional task?

As Long (1982, 1985) and Long & Sato (1983) have emphasized in their seond language acquisition studies, what I have described as Plane 3 in the discourse—interaction—is a key feature for comprehensible input. The study reported here calls into question traditional assumptions about reading ease. When evaluating materials in all three planes of discourse, all information on the page needs to be considered. Only then can the effectiveness of a particular text be evaluated. The most effective textbooks, then, would be those which provide the greatest amount of comprehensible input through verbal and nonverbal means. Comprehension questions, at increasingly more interactive levels of Bloom's Taxonomy, would be another important indication of effectiveness.

## Implications

Since these conclusions are based on a case study of two science textbooks and the students assigned to read them, they must be tempered by the possibility that the experimental portion of the study is unique to these textbooks and these students. Nevertheless, the study has pedagogical implications for the high school science curriculum in particular, and perhaps for other curriculum domains as well. It reflects a concern for teaching language as communication—for teaching use, rather than grammaticality of usage. Content area teachers need to evaluate textbooks from the perspective of the way the text



comunicates information to the readers. As Widdowson (1979a) states, the real purpose of reading is "to derive from this interaction something which sustains or extends (the reader's) conceptual world" (p. 180). This claim implies that:

(l) Textbook writers who propose to write texts for limited English proficient students need an understanding of the features that promote comprehensibility: interaction and contextual clues. Sheltered English for science does not necessarily imply simplification of grammatical usage, i.e., making shorter sentences with shorter words. (*Sheltered English* is content area instruction in English provided for nonnative English speakers who have intermediate to advanced fluency in English [California State Department of Education, 1984]). Sheltered English is characterized in part by more contextual clues and interactions than would be usual among native English speakers. Interactions and redundancy in contextual clues through repetitions, expansions, and exemplifications in the verbal text and nonverbally through illustrations, charts, and photos are critical supports for the reader. The longer text may be better for the nonnative English speakers because of the interaction and redundancy factors.[3]

(2) Textbook selection for science should be based on the quality of science information conveyed through all planes of the text, not on readability formulae alone.

(3) Content area teachers need to teach their students how to interact with the textbooks. Teaching reading for the information of science involves teaching particular rhetorical functions that appear in science textbooks. For example, deductive paragraphs begin with generalizations and contain additive, contrastive and evaluative information.

(4) ESL teachers and content science teachers can work together to help students learn to interact with texts. Nonnative English speakers who are ready for sheltered English instruction can benefit from academic program texts if the science teacher provides access to the material by teaching students how to read the textbook for the scientific information it contains. The ESL teachers can begin the process of preparation for content instruction by integrating a functional-notional approach using authentic material from science textbooks in the ESL classroom. Such instruction integrates the purposes for communicating—functions like explaining an idea or making a judgment—with the notions of grammar and vocabulary taught in traditional language classes. ESL students may be trained to predict the flow of a paragraph from generalization through additive informatives to particularizations. Both ESL and content area teachers can provide study skills strategies of the SQ3R type for their students.[5] And certainly, both the ESL and content teachers can participate in sheltered English training activities, exchange vocabulary lists, and share course outlines. Something as simple as making sure the ESL teacher has a copy of the content area textbook to use as a reference is an important initial step.

## Suggestions for Sheltering the English of Science Textbooks

Below are 15 starter ideas for ESL and content teachers to assist the limited English proficient reader in gaining knowledge from textbooks. This preliminary list is provided here as a sample of the range of activities teachers can use. These sheltering suggestions enhance interaction and context clues (1, 2, 6, 9, 15); modify the presentation of the material (3, 8, 11, 12); raise student awareness of the structure of the information (5, 10, 13); and personalize the learning to the students' needs (2, 7, 14).

1. Use confirmation checks: Is this what it means?
2. Use comprehension checks: Do you understand what it says?
3. Use clarification requests: What do you mean by that?
4. Repeat or expand through restatements, antonymns, synonyms, explanations, diagrams, pictures, and other examples.
5. Use a variety of question types at increasingly higher levels of Bloom's Taxonomy and both display and referential questions. *Display questions* seek only answers to what the teacher already knows, while *referential questions* ask for information which the questioner doesn't have.
6. Use problem-solving, task-based, and cooperative learning activities in the classroom and for homework assignments.
7. Personalize the lessons to the students' background.
8. Provide wait time and brainstorming for student responses.
9. Use a multisensory approach.
10. Provide various study skill strategies. Common questions for the students to pose about material are: What does the title mean? What do you already know about the topic? What do the illustrations tell about the topic? What do the comprehension questions indicate to be of importance? (Several academic teachers I've observed assign the students to write 10 to 25 questions per chapter for which they will find answers.)
11. Model the reading aloud while the students begin silent reading. The teacher poses questions while reading aloud to show the prediction stratgegies used while reading. (I've used this strategy for both content area and literature readings and noticed I could focus on, expand, and personalize new vocabulary through the read aloud/question/predict strategy.)
12. Ask students to paraphrase key ideas after reading.
13. Have the students transfer the information to a different form. Widdowson (1979b) suggests nonverbal translation from prose text to charts and vice versa to show relationships, such as concept-class characteristics.
14. Have students personalize key concepts by role playing.
15. Set up debates to clarify and evaluate key issues.



What began as a detailed discourse analysis of the textbooks used in secondary science classrooms has evolved into a brainstorming on sheltering stategies for content instruction. The reader is invited to extend the list of strategies for all content instruction.[5] ■

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[2]I conducted my studies in the early 1980s and first presented the results nationally at the 1984 University of Southern California Partnerships in Research: Universities and Secondary Schools Symposium, cosponsored by CATESOL. My dissertation won second place in the 1984 NACBE/NABE international competition: Outstanding Dissertations in Bilingual Education.

[3]For a detailed discussion of these data collection procedures and findings, see Addison (1983).

[4]This is consistent with Wilga Rivers' view that repeated presentation should precede production practice. I amplify this by claiming that repeated and varied presentation enriches the input and increases the probability that the input will become comprehensible.

[5]SQ3R is a reading strategy used in high school classes. Its steps are: scan, question, read, recite, review.

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