Academic English in Fifth-grade Mathematics, Science, and Social Studies Textbooks

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ACADEMIC ENGLISH IN FIFTH-GRADE MATHEMATICS, SCIENCE, AND SOCIAL STUDIES TEXTBOOKS

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Abstract

This study expands on previous National Center for Research on Evaluation, Standards, and Student Testing (CRESST) work that has undertaken the articulation of the academic language construct for broad educational purposes. The primary goal was to describe the language of textbook selections in terms of vocabulary, grammar, and organization of discourse for test development. Specifically, the work reported here has focused on the academic English used in fifth-grade mathematics, science, and social studies textbooks and will contribute to the conceptual discussion of the nature of academic language, and will provide concrete guidelines for test development. The vocabulary analyses included measures of lexical diversity, word frequency, and frequency of multisyllabic and derived words, as well as variety of clause connectors and frequency of nominalizations. In addition, academic vocabulary was identified as specialized (within a discipline) and general (across disciplines). The grammatical analyses included the following features: sentence type, clause type, passive verb forms, prepositional phrases, noun phrases, and participial modifiers. The discourse analyses captured the organizational features of the selections on three levels: rhetorical mode (e.g., *exposition and persuasion*) and both dominant and supporting text features (e.g., *description, classification,* and *paraphrase)*. The analyses of textbook language reported here have provided the bases for a profile of typical texts in each subject at the fifth grade that will be part of the foundation for developing academic language proficiency tests. We conclude by illustrating how these profiles can be used in the creation of test specifications.

CHAPTER 1:
INTRODUCTION

Under the No Child Left Behind (NCLB) legislation of 2001, educators face the challenge of assuring that all students ultimately meet rigorous academic standards and demonstrate yearly progress towards that goal. For English learners, the task is especially challenging because they are faced with acquiring English language skills at the same time they are expected to learn academic content in English in a range of subjects. The role of language in the different subject areas impacts English learners' ability to learn across disciplines (e.g., Butler & Castellon-Wellington, 2000). Thus, in order to provide adequate support and assess progress in language and other subject matter, it is important for educators to understand the specific role of English within academic subject areas such as mathematics, science, and so forth. Research that focuses on English language development (ELD) in and for academic contexts can play a critical role in helping to address the challenges faced by educators and students (e.g., August & Hakuta, 1997; Gottlieb, 2003; MacSwan & Rolstad, 2003).

This study expands on previous work involving English learners conducted at CRESST by further specifying the construct of academic language and refining a research procedure that can be extended to additional grade levels and subject areas. Specifically, we analyzed textbook language in three subject areas—mathematics, science, and social studies—at the fifth grade. The analyses yielded descriptions of vocabulary, grammar, and organization of discourse. The immediate goal is to use the information in this report to generate test specifications for academic language tasks for assessing the English language proficiency of English learners. The information from this research effort, however, could have broader applications by providing empirical evidence about the nature of the language all students must understand and use in and across subjects. Test developers, teacher trainers, curriculum developers in subject areas, and textbook writers will all benefit from this information.

The report is organized as follows: First, in this chapter, previous CRESST research on academic language is summarized; next, our current research focus and goals are discussed, followed by an overview of the methodology used in the study. Chapters 2 through 5 present the findings, including descriptive statistics about the text selections in Chapter 2, a discussion of the lexical features identified in texts in

Chapter 3, grammatical features in Chapter 4, and discourse (organizational) features in Chapter 5. Chapter 6 discusses the findings and demonstrates their applicability to CRESST test development work. Chapter 7 provides conclusions and recommendations.

Previous CRESST Research on Academic Language

The work reported here builds on multiple CRESST studies, including research on subgroups of English learners, academic language proficiency, the validity and use of standardized English-language content assessments with English learners, and operationalization of the academic language construct.[1] The initial work began with a focus on the use of test accommodations with English learners on standardized content assessments and the articulation of subgroups of English learners on the basis of multiple variables (Butler & Stevens, 1997).[2] Language proficiency was identified as one of the most important variables "in characterizing English language learners and…[as] essential for identifying the interface between language and content knowledge in standards-based assessments" (p. 24). In the conclusion, the authors call for the development of measures of academic language proficiency based on the documentation of classroom language.

Subsequent research was undertaken to characterize the features of academic language at the middle school level. Butler, Stevens, and Castellon-Wellington (1999) created content-based academic language tasks for seventh-grade classrooms using social science texts as the content base. This research documents initial steps towards operationalizing and assessing academic language, specifically for the purpose of "establishing a threshold level of academic language proficiency in English through the use of a series of cross-modality assessments that build on language commonalties in different content areas" (p. 2). In other words, the goal of the work was to develop specifications for assessing academic language proficiency through the use of different types of authentic reading and writing tasks that reflect language use common to multiple subjects—mathematics, science, social studies, and language arts. Establishing a threshold level of academic language proficiency

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[1] *Operationalize* in this context means providing descriptions of academic language based on empirical data that include enough specificity to allow for the development of specifications and tasks/items for assessing academic language proficiency.

[2] The word *content* used in these earlier studies refers to school subjects such as mathematics, science, social studies, etc. In this report, we use the term *subject* instead to refer to mathematics, science, and social studies to avoid confusion with linguistic use of the term "content word" used in Chapter 3.

involves determining at what point student performance in the classroom and on standardized content assessments reflects subject-area knowledge and not the lack of English language skills.

CRESST researchers concurrently investigated performance differences between native English speakers and English learners on standardized content assessments (Abedi, Courtney, & Leon, 2001; Butler & Castellon-Wellington, 2000), the language demands of standardized content assessments in English (Bailey, 2000), and the relationship between the language assessed on a language proficiency reading subtest and the language used on standardized content assessments (Stevens, Butler, & Castellon-Wellington, 2000). Butler and Castellon-Wellington (2000) reported the differential performance of English learners on content assessments based on language proficiency classification (e.g., limited English proficiency). The findings indicate issues of test validity for this group of learners, and again calling for measures of academic language proficiency, a language register that is relevant to the language of standardized assessments. Analysis of the language demands of standardized mathematics, science and English language arts (ELA) (i.e., reading comprehension) assessments revealed that all three content areas present challenging syntax and vocabulary to greater or lesser degrees in the majority of test items (Bailey, 2000). However, mathematics and science items differed from ELA in the amount of connected discourse students are required to process.

In Stevens et al. (2000), the language assessed in an English proficiency reading subtest for seventh-grade English learners was found to differ substantially from the type of language used in a social studies assessment, for example, in terms of having less specialized content vocabulary, less complex syntax typically associated with subject-area materials, and a smaller variety of item-response formats and prompts. Additionally, despite the fact that all the students in this study were grouped as "limited English proficient" by the subtest, the subject-matter assessment results showed differential levels of performance within the group, indicating that the English assessment may not have adequately separated groups of students at the upper levels of the limited-English-proficiency range, and that, as indicated by the students, factors other than language, such as opportunity to learn, contributed to performance.

More recent CRESST work has focused on operationalizing the academic language construct and documenting the features of academic English that are discipline-specific and those that cut across subject areas for the purposes of developing language assessment specifications and tasks across grade clusters and subject areas. Based on a series of observations of fourth-, fifth-, and sixth-grade mainstream science classrooms, Bailey, Butler, LaFramenta, and Ong (2004) developed matrices to illustrate the intersection between contexts of instruction (science concepts, vocabulary, and application instruction) and language functions, repair strategies, and classroom management talk. There was great variability in the degree to which teachers held students accountable for verbalization of their knowledge, with only some teachers, for example, requiring students to provide fully elaborated explanations for their scientific claims. This source of variation in teacher discourse style has implications for student learning and assessment and is documented for other subject areas (e.g., mathematical discourse) as well (e.g., Kazemi, 1999). Overt instruction of subject-area vocabulary (i.e., specialized academic vocabulary) was frequently made, however, primarily relying on examples rather than on formal definitions, and occurring more often than overt instruction of general academic vocabulary (e.g., vocabulary words that are used across subject areas in academic contexts).

In response to the call for providing stronger evidentiary bases to educational research (Feuer, Towne, & Shavelson, 2002; National Research Council, 2002), Bailey and Butler (2003) argued for and presented an evidence-based research framework for operationalizing academic language. The framework lays out six specific types of evidence to serve as bases for describing academic language. Relevant empirical data has been culled from the CRESST research mentioned above, including data on fourth- through eighth-grade textbooks and materials, third-, seventh-, eighth- and eleventh-grade content assessments, and fourth- through sixth-grade classroom discourse. Currently, research is being conducted to fill in gaps where no empirical research exists.

In Butler, Lord, Stevens, Borrego, and Bailey (2004) the evidence-based framework is applied at one grade level to supplement the classroom discourse research mentioned above. Butler et al. (2004) focused on science and mathematics standards and textbooks at the fifth-grade level. Analysis of the textbooks helped to characterize: (a) the nature of the language students are expected to read and understand and (b) the language demands implicit in the tasks they are called upon to perform. Features investigated include language functions that were exemplified in the texts and implicitly required in the tasks, grammatical features including sentence length and number of embedded clauses, and lexical features including the identification of general and content-specific academic vocabulary. Marked differences were observed between the types of texts that appear most frequently in science textbooks compared to those in mathematics textbooks, providing empirical evidence of the existence of discipline-specific language. Additionally, the analyses of functional language show that while texts in science and mathematics vary considerably, the language functions students must use in the two subject areas and the language structures associated with those functions are similar, providing evidence of general academic language beyond the vocabulary level as well.

The CRESST studies have played a crucial role in shaping our conceptual understanding and in refining our research design. Specifically, we have been able to capitalize on the methodologies that were developed for the characterization of textbook language (Butler et al., 2004). Other research efforts (e.g., Cazden, 2001; Chamot & O'Malley, 1994; Reppen, 2001; Scarcella, 2003; Schleppegrell, 2001; Short, 1993) provided guidance in the choice of the different analyses and are referred to in the general methodology discussion and other relevant chapters below. In the next section we present our research focus and goals for the current study.

Current Research Focus and Goals

As a continuation of our effort to operationalize academic language, the study reported here provides descriptions of the language used in selected, representative fifth-grade mathematics, science, and social studies textbooks. These data expand on previous, exploratory analyses of fifth-grade mathematics and science textbooks, which provided preliminary empirical data on the language being used in the two subjects (Butler et al., 2004). Our work is focused at the fifth grade because students at this grade are expected to use reading to aid in their learning and not concentrate on the development of reading skills per se (Reppen, 2001).

The modality of reading was selected for this stage of research; test development efforts with other modalities will follow. We began with reading because it is a focal point of the NCLB legislation for all students and presents an especially critical burden for English learners, who must also be tested annually. All students are expected to read at grade level and must have the ability to do so in order to access and demonstrate knowledge on standardized assessments. In addition, reading provides increasingly complex linguistic input to students from grade to grade since the reliance on reading comprehension in instruction and assessment across subject matter increases with grade level (RAND, 2002).

The information from the current study will be used for test specification development for English language tasks appropriate for fifth grade. Specifically, descriptions of the lexical, grammatical, and organizational features of the textbook selections will allow us to create a profile of typical texts in each subject. The profiles will be part of the foundation for developing specifications and academic language assessment tasks and items. Characterization of texts across a range of subject areas will provide information on content-specific language demands, while characterization of texts by grade level or cluster will provide data on developmental demands.

To provide the necessary empirical foundation for test development, two research questions guided our current efforts. Those questions are:

1. What are the linguistic characteristics of mathematics word problems and multi-paragraph texts in science and social studies at the fifth-grade level?
1. How do the identified characteristics of texts in different subject areas compare to one another?

Answers to the two questions provide the empirical evidence needed for generating specifications for academic language reading tasks by allowing us to systematically describe the nature of language use in each type of text analyzed. The range and type of vocabulary along with the grammatical structures used to accomplish text purpose is synthesized into an academic language framework that will facilitate not only test development but eventually curriculum and materials development as well as professional development. We turn now to a discussion of the general methodology used in this study.

General Methods

This section introduces the methodology used in this study. First we present our research approach in association with the two research questions. Then we present the procedures followed in the study, including text selection, coding development, analysis, and determining accuracy and reliability of coding.

Research Approach. To address the research questions, a range of analyses were applied systematically to the language in the mathematics, science, and social studies textbook selections. Each research question is presented below along with an explanation of the types of analyses used to help answer the question.

> Question 1. What are the linguistic characteristics of mathematics word problems and multi-paragraph texts in science and social studies at the fifth-grade level?

One of the first steps in the development of reading tasks is the selection of texts on which to base those tasks. Guidelines that provide characteristics of texts at the appropriate level(s) are needed for the selection process. The guidelines then become part of the test specifications. To present the text characteristics for the current effort, we produced text profiles for the subject areas that include key components of the text types to be used.

To characterize the mathematics word problems and the science and social studies extended texts, we began by generating descriptive data for each selection in the study. Then, to more fully describe the texts, we looked specifically at the areas of vocabulary, grammar, and discourse mentioned above. The discussion here provides an overview of the types of analyses conducted; the analyses are fully elaborated in their respective chapters below.

Descriptive Data. Measures of sentence length provide basic descriptive data and have long been associated with reading difficulty (Zakaluk & Samuels, 1988). Longer sentences tend to pose greater challenges for students. These challenges are found to be even greater for students whose home language is not English (Abedi, Lord & Plummer, 1997). For this reason sentence length is an important factor for creating the subject area profiles. Other basic descriptive data include such information as number of words, sentences, and paragraphs in the selections, mean sentence length calculated by topic and subject area (see the discussion on text selection later in this chapter for specific information on the number of selections per topic and the number of topics per subject area), and mean number of sentences per paragraph. The summary information is included in each subject-area profile. These descriptive data, presented in Chapter 2, provide indicators of similarities and differences in the nature of texts used in subject areas at the fifth grade.

Lexical Data. For vocabulary, features believed consequential in defining academic vocabulary and for describing the acquisition and use of vocabulary in academic settings were identified in all text selections in mathematics, science, and social studies. First, lexical diversity, a measure that reflects the variety of vocabulary in a given text, was calculated by dividing the number of different words (word types) by the total number of words (tokens) in that text. This lexical diversity ratio is important in characterizing selections because it helps establish the range of vocabulary students must be able to understand. Vocabulary that can be identified as part of the academic English lexicon by its usage in academic contexts includes both the specialized word usage within academic disciplines, as well as the general academic vocabulary not exclusive to any one discipline.

To help us specify and define what constitutes an academic word beyond the contextual aspects, we also investigated discrete features of the vocabulary of the text selections that included: (a) vocabulary that appears on low frequency word lists for the fifth-grade level; (b) vocabulary that contains three or more syllables; and (c) vocabulary that is morphologically derived from root lexical forms.

Word frequency and the frequency of multisyllabic words and derived words serve as indices of difficulty and will be important in the future for comparative purposes with texts from other grades. The vocabulary identified for these three features was compared to the vocabulary identified as academic vocabulary to determine degree of overlap (see Chapter 3 for a discussion of the identification process for academic vocabulary). Were the overlap significant with any one (or more) of the features, it might be possible to use that feature(s) to identify academic vocabulary in future research and test development efforts to streamline the identification process.

Analysis of two additional lexical-level features was also included: frequency and variety of clause connectors and frequency of nominalizations. Specifically, the identification of adverbial clause connectors (often called adverbial subordinators) was an important part of the lexical analyses because they frequently signal meaning relationships between clauses. Since research suggests that students may not interpret these words correctly, resulting in possible misunderstanding of the meaning relationships they encode (see for discussion, Celce-Murcia & Larsen-Freeman, 1983; Halliday & Hasan, 1976), the frequency of their occurrence should be reflected in the text profiles and taken into consideration in the test development stage. Nominalizations were included because they can increase semantic complexity (Martin, 1991) and provide additional descriptive information about lexical usage in academic texts. Discussion of the lexical analyses is provided in Chapter 3.

Grammatical Data. For grammar, we looked at the following features: percentages of sentence types used (i.e., simple, compound, complex, and compound-complex), numbers of dependent and coordinate clauses (including percentages of total clauses), occurrences of passive voice verb forms, prepositional phrases, noun phrases, and participial modifiers. Since clause types have been found to be a factor in student test performance with higher frequency of dependent clauses associated with greater processing difficulty, range and frequency of sentence types, which reflect clause usage, are important considerations in text selection for assessment purposes (see Lord, 2002). Passive voice verb forms, prepositional phrases, noun phrases, and participial modifiers contribute to length and/or semantic complexity in texts, often increasing the processing load for the reader. They are also identified with academic prose (see Schleppegrell, 2001, 2004, for a review), and are therefore important features to note in characterizing fifth-grade texts. Discussion of the grammatical analyses is provided in Chapter 4.

Organization of Discourse. For discourse, we looked at the organizational features of the selections in the study—the language functions and devices writers used to express ideas and present factual information. In addition to language functions, which are a key component of the language that students must use to interpret and derive meaning from texts (Butler et al., 2004), writers often use different types of writing devices to provide additional detail, to exemplify a point, or to ensure reader comprehension, while they use other techniques to provide instructional guidance to students (e.g., by referring them to graphics or prior lessons). Therefore, in order to capture a broad spectrum of the features that exist in the textbooks, we analyzed both functions and additional features used by writers to convey ideas. The discussion of organizational features (Chapter 5) shows how our analyses concentrated on three levels of textual organization: rhetorical mode, dominant text features, and supporting text features.

The data characterizing the linguistic features of fifth-grade mathematics, science, and social studies textbooks provide a basis for the text profiles and for the content of academic language proficiency assessment tasks and items at this grade level. These data, however, required further analysis before they could be used in test specifications for an assessment of general academic language proficiency. The second research question guided the subsequent analyses.

> Question 2. How do the identified characteristics of texts in different subject areas compare to one another?

The answer to the second research question required synthesis of the descriptive data and the linguistic analyses (Chapters 2-5). The first step involved synthesis of the descriptive, lexical, grammatical, and discourse data into "profiles" of language for each subject area (Chapter 6). The subject-area profiles were then compared, allowing commonalities and differences to be systematically compiled. Using analysis of variance (ANOVA) procedures and confidence interval calculations we were able to determine which of the differences across the three subjects in terms of key descriptive, lexical, and grammatical features are statistically significant. The points of commonality will later become candidates for inclusion in general academic language proficiency assessment tasks and items. Points of difference are possible candidates for tasks and items that are focused on the language of specific subject areas. The discussion turns now to our research procedures.

Procedures

This section provides a discussion of the procedures followed in the identification and analysis of the textbook selections. The discussion includes (a) text selection rationale and procedure, (b) analysis procedures, and (c) accuracy and reliability procedures.

Text Selection Rationale and Procedure. An important first step was to determine which texts would be selected for analysis in the three subject areas—mathematics, science, and social studies. We needed to determine which types of texts students encounter most frequently within and across subject areas; thus we needed texts that are both representative of *typical* texts and of sufficient length to provide material for test development. The word problem was established as the unit of analysis for mathematics for two main reasons: (a) Word problems provide a greater range of language use than other text types in mathematics textbooks, and (b) characterizing the language demands of word problems in textbooks will also best inform assessment development efforts, that is, the language of word problems mirrors the language that students commonly encounter on mathematics assessments that rely on word problems in addition to straight computation.

Restricting our focus on word problems may of course bias the results we obtain for mathematics and may not therefore be representative of print materials prepared for use in other context such as during mathematics instruction. We identified two types of word problems in the textbooks: those that include and require use of graphics to solve the problem and those that do not. For our research, we chose word problems without graphics and a minimum of two sentences, at least one of which must be a declarative statement that provides the set up for solving the mathematics problem.

Based on previous research (Butler et al., 2004), multi-paragraph texts were identified as the most frequently occurring type of text in science and social studies textbooks and were, therefore, chosen for analysis in this research (see Appendix A for examples of selected texts from mathematics, science, and social studies).

The text selection process began with identification of topics in the California subject-matter standards for fifth grade in each subject area. Three textbooks from different publishers were selected from the list of California-approved textbooks for each subject area as the sources from which to select the samples. Three were chosen in order to reduce bias (e.g., different textbooks might have different writing styles) that could result from analyzing textbook samples from only one publisher. We then compared the topics in the subject-matter standards with the textbook topics to identify the closest matches possible in content (e.g., *Matter*, *Storms*). Since textbooks varied in their treatment of topics, we further narrowed our focus to topics that occurred in all three textbooks with similar subtopics, vocabulary, and concepts in order to insure adequate and comparable topic coverage. For instance, selections in each science textbook on the topic *Storms* included subsections on hurricanes and tornadoes; the similarity in subsections supported the topic *Storms* as a candidate for inclusion in the research. For each of the three subjects we chose four topics; we then chose three selections for each topic for a total of 12 text selections per subject. In total, 36 selections were identified for analysis (see Table 1 for the topics selected across subjects).

Table 1

Topics Selected for Each Subject (n=3 selections per topic)

Mathematics	Science	Social Studies
Decimals	Matter	Declaration of independence
Fractions	Plants	Industrial revolution
Multiplication	Storms	Pilgrims
Ratio	Water cycle	Slavery

Note. Total number of selections = 36.

The fifth-grade textbooks we utilized in this study averaged 567 pages each. To give a concrete sense of the amount of data that we analyzed in each textbook, we calculated the total number of textbook pages selected for analysis, and divided the number by the total number of pages in the textbook. On average, the volume of data that we have analyzed constitutes around 3% of each of the nine textbooks. In absolute terms, this totals 154 pages of text analyzed. In typical fifth-grade textbook layout we found this includes an average of one illustration per page. There is little variation in the average proportion of text pages selected across subject areas, ranging from 2.60% of the text in social studies textbooks and 3.03% of the text in science, to 3.43% in mathematics.

In mathematics, we selected a number of word problems for each topic, carefully balancing the number of word problems and the total number of words selected from each textbook. In science and social studies, one multi-paragraph passage per topic was selected per textbook. The passages all begin at a natural starting point for the topic, often signaled by a header in the textbook, and end at a natural breakpoint. We attempted to select texts that were of sufficient and similar length for linguistic analyses across the three subjects, though there is some variation in length due in part to differences in presentation across textbooks and also due in part to subject matter differences (e.g., the depth of topic coverage or the variety of subtopics presented within a topic). The social studies selections, for example, tend to be longer than the science selections. We felt it was more important to ensure a coherent piece of text by including the beginning and end of each selection rather than stopping abruptly in the middle of a selection to achieve uniform word length across subject areas and textbooks. Once all the selections were identified for a subject area, they were entered into electronic format for data analysis. To standardize comparisons across subject areas, we converted raw data into percentage, ratio or rate data (i.e., number of instances of a feature per 100 sentences).

Visuals, graphics, and primary source excerpts were not included at this stage of the study with the exception of some social studies selections that included one- or two-sentence excerpts or quotes from primary sources that were an integral part of the selection. Future analyses should be conducted to examine the role of primary sources and visual information used in conjunction with linguistic input.

Analysis Procedures. A total of seven researchers were trained for the different analyses with pairs of researchers focusing on descriptive, lexical, grammatical, and discourse features respectively. Guidelines were developed specifically for each type of analysis by the researchers responsible for the particular area of investigation.[3] The guidelines evolved as the analytic process for each type of analysis was refined. Two theoretical linguists carried out the grammatical analyses, and researchers with applied linguistics training focused on the lexical and discourse pieces. The analyses are discussed in detail in their respective chapters below.

Accuracy and Reliability Procedures. To help ensure the strength of our results, accuracy or reliability checks, as appropriate, were conducted at each stage of the research for all the analyses performed on the textbook selections. The general procedures followed are reported here for each type of analysis. The results are reported in the respective chapters below.

Accuracy checks were conducted on the analyses that were non-subjective (e.g., word counts), while reliability was conducted for those analyses that required the judgment of raters based on specific criteria. We established a goal of 95% or higher for the accuracy checks and 85% or higher interrater reliability.

We conducted accuracy checks for the descriptive analyses, including number of words, sentences, and paragraphs per selection, as well as mean number of sentences per paragraph and mean sentence length by topic and subject area. In addition, accuracy checks were conducted for counts of multisyllabic words of three or more syllables, calculations of lexical diversity, and counts of words appearing on low frequency word lists. Initial counts were established by the automated Computer Language ANalysis (CLAN) programs of the Child Language Date

[3] The Academic English Language Proficiency (AELP) Guidelines for the Linguistic Analysis of Texts are being prepared for general distribution by CRESST.

Exchange System (CHILDES), (MacWhinney, 1995; MacWhinney & Snow, 1990); project researchers then verified the counts manually.

We calculated reliability between coders for identification of subcategories of academic vocabulary. We also calculated reliability for identification of derived words, noun phrases, prepositional phrases, dependent clauses, participial modifiers, passive voice, and nominalizations. For our analyses of organizational features, we calculated interrater reliability for identification of rhetorical mode, dominant text features, and supporting text features.

We turn now to Chapter 2 for a discussion of the descriptive analyses.

CHAPTER 2:
DESCRIPTIVE ANALYSES

One of the first steps in this research was to conduct descriptive analyses of the text selections, which, along with the other analyses, aid in the construction of profiles of text characteristics that typify each subject area. The profiles can be used to guide text selection and item development efforts. Additionally, these analyses helped us to identify the degree of uniformity and variation in language use across subject-area topics. We first describe the procedures for analyzing the text selections and then present the results.

Procedures

First, all of the text selections were typed into electronic files and checked for typographical accuracy. Next we ran computer-assisted language analyses using CLAN to determine the number of words and sentences in each selection. The mean number of sentences and mean sentence length, as well as measures of central tendency and dispersion for each selection were calculated using procedures of the statistical package SPSS. One researcher performed all the analyses, and a second researcher conducted accuracy checks on a third of the selections, establishing an accuracy rate of 99%.

Findings

The results of the analyses are presented below by subject area, beginning with mathematics. A summary at the end compares the results across subjects.

Mathematics

Table 2 provides the descriptive data for mathematics overall and by topic.[4] The mathematics selections have a total of 212 word problems with 7,008 words total and a mean number of 33 words per word problem. The subject area mean number of sentences per word problem is 3, with a range of 2-7 sentences. It is important to note that all word problems selected for analysis deliberately consisted of two or

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[4] In the results chapters (2-5), the tables provide data carried out to two decimal points, while data in prose is rounded to the nearest whole number.

more sentences, even though word problems consisting of only one sentence do exist.

The subject area mean sentence length is 11 words with a range of 1-39 words per sentence. The median values range from 9-11 words, virtually identical to the topic means, suggesting normal distributions (i.e., the mean reflects a central tendency in the data). Comparing across topics there is little variation in mean number of sentences per word problem (*SD*=.51) or in mean sentence length (*SD*=.86).

Table 2

Descriptive Data for Mathematics by Topic

Statistics	Decimals	Fractions	Multiplication	Ratios	Subject area total/mean/range (*SD*)
Total no. of words	1788	1716	1650	1854	7008
Total no. of word problems	57	56	52	47	212
Mean no. of words per word problem	31.37	30.64	31.73	39.45	33.06 (5.06)
Mean no. of sentences per word problem	2.95	2.96	3.17	3.43	3.13 (.51)
Range of no. of sentences per word problem	2-6	2-6	2-5	2-7	2-7
Mean no. of words per sentence	10.80	10.40	10.35	11.63	10.80 (.86)
Median sentence length	8.67	9.50	10.00	11.00	9.79
Range of no. of words per sentence	1-30	1-25	1-25	1-39	1-39

Science

Table 3 provides the descriptive data for science overall and by topic. There are 7,261 words total in the twelve selections, with an average of 605 words and 11 paragraphs per selection. The subject area mean number of sentences per paragraph is just over 4, with a range of 1-8 sentences. The subject area mean sentence length is 13 words with a range in sentence length of 1-37 words. The median sentence length across topics ranges from 12-13 words, almost identical to the means. The standard deviations for subject area mean paragraph and mean sentence lengths are .45 and .86, respectively.

For science, the descriptive statistics show consistency within and across topics. However, the average length of the selections varies from 531 to 673 words, which directly affects the number of paragraphs and sentences in each selection. Even with this variation, overall statistics such as the mean number of sentences per paragraph are similar. This suggests relative consistency in how the selections are structured at the paragraph and sentence levels across topics.

Table 3

Descriptive Data for Science by Topic

Statistics	Matter	Plants	Storms	Water cycle	Subject area total/mean/range (*SD*)
Total no. of words	2018	1938	1711	1594	7261
Mean no. of words per selection	672.67	646.00	570.33	531.33	605.08 (66.37)
Mean no. of paragraphs per selection	12.67	12.33	11.00	9.33	11.33 (1.78)
Mean no. of sentences per paragraph	3.85	4.18	4.27	4.44	4.18 (.45)
Range of no. of sentences per paragraph	1-8	2-8	1-8	1-7	1-8
Mean no. of words per sentence	13.83	12.78	12.28	13.08	12.99 (.86)
Median sentence length	13.33	12.67	12.33	12.33	12.67
Range of no. of words per sentence	3-34	1-30	3-34	3-37	1-37

Social Studies

Table 4 provides descriptive statistics for social studies overall and by topic. The total number of words in the social studies selections is 10,878, with an average of 907 words per selection. There is a subject area average of 17 paragraphs per selection, with a mean number of 4 sentences per paragraph and a range of 1-9 sentences. The subject area mean sentence length for social studies selections is 14 with a range of 3-43 words per sentence. The median sentence length across topics ranges from 12-14, close in value to their respective means. Comparing across topics, there is little variation in either subject area mean paragraph length or mean sentence length (*SD*=.48 and *SD*=.75 respectively).

Table 4

Descriptive Data for Social Studies by Topic

Statistics	Declaration of independence	Industrial revolution	Pilgrims	Slavery	Subject total/mean/ range (*SD*)
Total no. of words	2,528	2,704	2,689	2,957	10,878
Mean no. of words per selection	842.67	901.33	896.33	985.67	906.50 (85.99)
Mean no. of paragraphs per selection	16.33	16.67	16.33	19.00	17.08 (2.35)
Mean no. of sentences per paragraph	3.56	4.00	4.40	3.93	3.98 (.48)
Range of no. of sentences per paragraph	2-8	2-8	1-9	2-8	1-9
Mean no. of words per sentence	14.58	13.55	12.56	13.40	13.52 (.75)
Median sentence length	14.17	13.33	12.00	12.33	12.96
Range of no. of words per sentence	4-33	3-41	3-31	3-43	3-43

For social studies, the descriptive statistics show little variation within or across topics, except that as with science, the selections differ in average length by as many as 143 words per selection. Even with this variation, paragraph and sentence data such as the mean number of sentences per paragraph are similar across topics.

Chapter Summary

Overall, differences in basic descriptive data among subject areas exist, but are minimal. Table 5 provides comparisons of the descriptive data for subject matter totals in the three subject areas.

Table 5

Comparison of Descriptive Data Across Subject Areas

Statistics	Mathematics	Science	Social Studies
Mean no. of sentences per word problem/paragraph (*SD*)	3.13 (.51)	4.18 (.45)	3.98 (.48)
Range of no. of sentences per word problem/paragraph	2-7	1-8	1-9
Mean no. of words per sentence (*SD*)	10.80 (.86)	12.99 (.86)	13.52 (.75)
Range of no. of words per sentence	1-39	1-37	3-43

The mean number of sentences per word problem in mathematics is 3; for science and social studies, the mean is 4 sentences per paragraph. The range of number of sentences per paragraph for science and social studies is nearly identical as well. At the sentence level, the mean sentence length is slightly shorter for mathematics at 11 than for science at 13 and social studies at 14 with a standard deviation of about 1 word per sentence for all three subject areas. In treating mathematics word problems and science and social studies paragraphs as comparable units of analysis, we found that mathematics word problems were shorter and used shorter sentences than paragraphs and sentences in either the science or social studies text selections.

We turn now to the analyses of the vocabulary, grammatical, and organizational features in the next three chapters, which will help to further specify the characteristics of these subject-area texts.

CHAPTER 3:

LEXICAL ANALYSES

Continuing our analysis of the same textbook selections described in Chapter 2, our goal in these lexical analyses was to examine the nature of vocabulary used in mathematics, science and social studies textbooks. The analyses, as already described in the General Methods section of Chapter 1, focus on key aspects believed consequential for the understanding and acquisition of vocabulary in academic settings. This includes determining the degree of diversity in vocabulary with a basic description of the number of unique words types, as well as identifying the academic English lexicon by word usage in academic contexts. For example, such contexts include the specialized use of vocabulary in academic disciplines (e.g., *thermal, multiplication*), as well as usage encountered predominantly in academic contexts but not exclusive to any one discipline (e.g., *synthesize, report*) (Nation & Coxhead, 2001).

To help specify and define what constitutes an academic word and what does not beyond these contextual aspects (i.e., specialized versus non-specialized uses), we also investigated discrete features of words in the text selections that included: (a) vocabulary that appears on low-frequency word lists for the fifth-grade level; (b) vocabulary that contains three or more syllables, and (c) vocabulary that is morphologically derived from root lexical forms. A synthesis of analyses is reported whereby we examine the degree of overlap between vocabulary meeting the low frequency, three or more syllable, derived, and academic vocabulary criteria. Two additional lexical-level analyses were conducted and are included in this chapter: frequency and variety of clause connectors and frequency of nominalizations. Both were viewed as potential hallmarks of printed texts in the academic setting.

For each analysis we provide information about raw amount (tokens), number of unique words (types), percentage of the total number of tokens and types for which different lexical features account. We also describe variation in the results of these analyses by topic and across the three subjects.[5] Again, the main emphasis is on differences across topics and subjects rather than across individual textbooks

[5] The lexical analyses are presented at the topic level rather than aggregated immediately to the subject level as they are for analyses of grammar (Chapter 4) and organizational structures (Chapter 5), since vocabulary is likely to be influenced by the choice of topic.

from which selections were made. Description of variation is provided quantitatively with calculations of standard deviations and minimum and maximum values, as well as qualitatively with examples of specific lexical items encountered in the different analyses.

Lexical Diversity

The lexical diversity measure shows the amount of variety in vocabulary items used in the different subject areas. That is, lexical diversity can be expressed as the number of different (i.e., unique) word types that appear in the text selections relative to the overall number of words used. The smaller the type/token ratio the less diverse the vocabulary in the selection—that is, the use of word types is repetitious (e.g., Phillips, 1973).

Procedures

To calculate lexical diversity, we used the type/token approach utilized in studies of language development (e.g., Templin, 1957; Sokolov & Snow, 1994). For such an analysis to be comparable across subjects and across topics within subjects, we standardized the total number of tokens (overall number of words) by using the first 450 words of mathematics word problems selections, or a passage selection in science and social studies. Prior research has shown that use of greater than 200 tokens yields more stable ratio calculations (Richards, 1987). Using the FREQ option of CLAN (MacWhinney, 1995; MacWhinney & Snow, 1990), the number of different word types within this 450 was tallied, and the ratio of the number of types to the 450 tokens was interpreted to provide an indication of lexical diversity in the textbook selections. The number of word types and the ratios of twelve selections (30% of the data) across the three subjects and topics were also manually calculated independently to check for accuracy of the CLAN program. With two exceptions the count of types and calculation of ratios were identical (CLAN treated the numbers that included a decimal point as separate words).

Findings

Mathematics. Table 6 provides the average number of different word types, the ratios by individual mathematics topics, and the overall subject-area averages for these values. We see that there is little variation in the average number of unique word types by topic (the overall subject-area standard deviation is below 10), although there is some difference in how well the averages represent the central tendency within topic: standard deviations for the topics range from just 2 for the selections in *Decimals* to 16 for the selections in *Multiplication.*

The topics all have a type/token ratio of approximately .40. That is, on average, slightly more than half the words in these selections appear more than once. This level of lexical diversity is somewhat low. In the spoken language of even relatively young children, type/token ratios are typically on the order of .50 (Pan, 1994). The lexical diversity in written language, especially in an academic context that is assumed to be purposefully introducing new lexical items to students would be expected to be greater.

Science. Table 6 provides the average number of unique word types, the ratios by science topics, and the overall averages for these values. There is close to a 20-word difference in the topic totals for number of unique word types, suggesting a degree of variation across topics in lexical diversity. This is confirmed by the standard deviation of about 13 for the subject-area average. *Matter* selections had the fewest number of unique word types, whereas the selections for the topic of *Storms* had the greatest. Within-topic variation as measured by the standard deviation is also quite high, similar across topics. Again the topics all have relatively low type/token ratios of approximately .40.

Social Studies. The total number of unique word types is 223 on average. Table 6 shows that there is only a slight degree of variation around this mean (standard deviation is 12), with a difference of 17 words from the lowest number of unique word types in *Industrial Revolution* selections to the highest in *Pilgrims* selections. Within-topic variation also differs greatly, with standard deviations ranging from about 4 for the *Pilgrims* selections to nearly 17 for the *Declaration of Independence* selections. The type/token ratios are close to .50. In other words, these selections introduce students to a new word every other word on average.

Summary. Comparing across the subjects we see that mathematics appears to be the most homogenous in terms of the variation in the number of unique word types across topic selections. According to examination of type/token ratios, neither mathematics nor science is as lexically diverse as social studies. Science, however, also presents the greatest degree of variation in the average number of unique word types across topic selections of any of the subject areas. The size of type/token ratios, in oral language at least, has been linked to the developmental stage of the addressee. Specifically, Phillips (1973) found smaller ratios in child-directed speech than in adult-adult talk. We hypothesize, on the one hand, that ratios will increase in size the higher the grade level of the textbook. On the other hand, maintaining a topic focus may maintain lexical diversity ratios as well, although these hypotheses await future study. Details on how often the individual words are used is something we turn to next in our examination of frequencies of words by subject-area.

Table 6

Lexical Diversity in Three Subjects by Topic (Standardized to 450 Word Tokens)

Statistic	Mathematics averages (*SD*)				Subject-area average (*SD*)
	Decimals	Fractions	Multiplication	Ratios	
Total no. of unique word types	195.67 (2.08)	196.33 (8.50)	189 (16.46)	192.33 (10.97)	193.33 (9.72)
Type/token ratio	.43 (.00)	.44 (.02)	.42 (.04)	.43 (.02)	.43 (.02)
	Science averages (*SD*)				
	Matter	Plants	Storms	Water cycle	
Total no. of unique word types	174.33 (11.93)	178.67 (12.86)	193.67 (10.69)	188 (14.00)	183.67 (13.24)
Type/token ratio	.39 (.03)	.40 (.03)	.43 (.02)	.42 (.03)	.41 (.03)
	Social Studies averages (*SD*)				
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of unique word types	225.33 (16.77)	212 (10.82)	229 (3.61)	224.33 (12.90)	222.67 (12.24)
Type/token ratio	.50 (.04)	.47 (.02)	.51 (.01)	.50 (.02)	.49 (.03)

Academic English Vocabulary

Chamot and O'Malley define academic language as "the language that is used by teachers and students for the purpose of acquiring new knowledge and skills…imparting new information, describing abstract ideas, and developing students' conceptual understanding" (1994, p. 40). However, prior attempts to operationalize academic language for research and practice purposes have proven elusive, with some ESL teachers suggesting academic language refers to the functions performed in the classroom and other teachers describing academic language as the specialized vocabulary used in subject areas (Solomon & Rhodes, 1995). Following Scarcella and Zimmerman (1998), we suggest that academic vocabulary, as one component of the broader academic language construct, comprises both general (e.g., *evidence, demonstrate* and *represent*) and specialized lexicons (e.g., *diameter, condenses,* and *abolitionist*), each of which students must acquire in order to become fully proficient in English in the academic setting. According to Nation (2001), at the tertiary education level, general academic vocabulary covers on average 8.5% of words in academic texts and specialized or technical vocabulary covers about 5% of words in academic texts (see also Bailey & Butler, 2003, 2004; Martin, 1976; Nation & Coxhead, 2001; Stevens, Butler & Castellon-Wellington, 2000 for reviews of academic vocabulary).

Procedures

The primary distinction in the coding schema developed by the research team for academic language analyses was between academic and non-academic usage of words (i.e., general service vocabulary, West, 1953). Phrases and compound words were coded as a single unit (i.e., the separate words in the phrase or compound were not counted as individual words). Within academic usage we also distinguished between specialized academic words and general academic vocabulary that cuts across disciplines. This distinction is important for future test development efforts that will attempt to target a broad cross-section of academic language and may therefore need to treat specialized vocabulary separately. During the course of coding we considered the sense intended in the selections and rated only the form and usage of words in the context of the given selections. Specifically, we had to be sure that the word-sense intended in the passage was referring to an academic concept (e.g., "Determine the centrifugal *force*" versus "Don't *force* him to do it"). This includes the specialized word sense often used in mathematics for some of the most common words in English. Prepositions for instance take on very precise and often unfamiliar usage in the mathematics register (e.g., Pimm, 1987, 1995; Bailey, in press). For example, the preposition "in" used in a phrase like "three in four" makes the relationship between the two numbers proportional, in this case three quarters or 75%.

If the intended meaning of a word was the same both in and out of the classroom setting, we considered the word usage to be non-academic. Throughout this process we were careful to avoid equating unfamiliarity with academic vocabulary. While we did not classify the use of seemingly arbitrary proper names (such as *Peter* and *Anne*) most often found in mathematics word problems as academic vocabulary, proper names related to content learning or crucial to the academic concepts of a topic were rated as specialized (e.g., *Continental Congress, Newton,* and *John Adams*). Similarly, measurement vocabulary and abbreviations for measurement and formulas were also rated as a subcategory of specialized academic vocabulary (e.g., *kilometer, km,* and *km/hr*). Colloquialisms/idiomatic expressions (e.g., *doffer, half-joked,* and *twister*), and verbatim speech formed their own separate subcategories if used in service of conveying academic concepts.

Initially, two researchers reviewed the definitions of academic language in the coding guidelines and identified examples in sample texts independently. Ratings on these selections were compared for agreement in two ways: (a) simple agreement between coders on distinguishing academic vocabulary from non-academic vocabulary, regardless of subcategory; and (b) simple agreement between coders on distinguishing between specialized and general academic vocabulary. Disagreements were discussed with the entire research team and the coding schema further refined to remove ambiguities in coding decisions.

Once the two coders reached 80% agreement on sample texts, they began the full coding of the selections independently. Reliability between the two coders was calculated on 12 selections, or a third of the data, in each subject area. These selections were chosen at intervals across the entire period of coding to ensure that fidelity to the coding guidelines was maintained. Simple agreement for distinguishing academic vocabulary from non-academic vocabulary averaged .96 (range .95-.99) for mathematics, .96 (range .95-.98) for science, and .92 (range .91-.93) for social studies. Simple agreement for distinguishing specialized academic vocabulary from general academic vocabulary averaged .84 (.74-.90) for mathematics, .94 (range .76-1.0) for science, and .91 (range .81-.97) for social studies.

The average number of words identified as academic vocabulary across selections is provided for each of the topics in the three subjects. The raw numbers of academic words and the subtypes we identified are also expressed as percentages of all words in the selections by topic. In addition, we also report the total number of unique word types among academic English words and the percentage of total word types for which these account in each topic.

Findings

Mathematics. The average number of words identified as academic vocabulary per mathematics selection is 60, or about 10% of the total number of words in the mathematics subject area (see Table 7).

Table 7

Academic Vocabulary in Mathematics by Topic [Percentage of Total Words in Brackets]

Statistic	Topic averages				Subject-area
	Decimals	Fractions	Multiplication	Ratios	average (*SD*)
Total no. of all academic word tokens	55 [9.21]	42 [7.61]	62.33 [11.22]	81 [13.15]	60.08 (21.25) [10.30]
Total no. of all academic word types	30 [11.76]	28.67 [11.75]	39.67 [16.12]	43 [16.42]	35.33 (12.12) [14.01]
Total no. of general academic word tokens	18.67 [3.10]	17.33 [3.13]	16.67 [2.99]	21.33 [3.51]	18.50 (6.27) [3.18]
Total no. of general academic word types	13.33 [5.39]	10.67 [4.39]	12.67 [5.07]	12.33 [4.75]	12.25 (5.91) [4.90]
Total no. of specialized word tokens	10.67 [1.74]	13 [2.40]	27 [4.90]	33.67 [5.45]	21.08 (13.19) [3.62]
Total no. of specialized word types	10 [3.69]	13.33 [5.45]	20.33 [8.37]	23.33 [8.85]	16.75 (10.05) [6.59]
Total no. of measurement word tokens	25 [4.25]	11.67 [2.08]	17.67 [3.16]	22.67 [3.63]	19.25 (8.71) [3.28]
Total no. of measurement word types	6.33 [2.55]	4.67 [1.92]	6.33 [2.55]	5.67 [2.17]	5.75 (1.71) [2.30]

Note. A very small number of colloquialisms (7 tokens) and proper nouns (8 tokens) were employed in the text selections, though not across all topic areas. These amounted to fewer than 1 word on average across the topics.

There is an average of 35 different word types, accounting for 14% of the different word types in mathematics overall. In total there are 275 different academic word types. There is some variation across topics in the magnitude of the standard deviations; these are about one third of the subject-area averages for both word tokens and types. Of the academic words, just 18 on average were identified as general academic words (e.g., *resulted, officially, reasonable*), with 12 of these identified as different word types. There is little variation in these numbers across topics.

On average, there are slightly more specialized academic words and measurement words than general academic words in mathematics selections. Such words include *denominator, rectangular, remainder* and *centigrade, Karat, kilometer* for specialized academic and measurement words, respectively. The number of different measurement word types, however, is small, accounting for just 2% of all word types in mathematics due to repetition of common measurement words such as *meter*. Specialized academic words, in contrast, account for nearly 7% of all word types. Table 6 also shows that there is considerable variation across mathematics topics both in terms of the average number of specialized academic words and measurement words used and in the number of different types used in the selections. Standard deviations for specialized word tokens and types especially, are in excess of half the mean values suggesting some topics, such as *Decimals,* have far less specialized vocabulary than others, namely *Multiplication* and *Ratios*.

Science. The average number of words identified as academic vocabulary in the science selections is 131, or about 21% of the total number of words in the science subject-area (see Table 8). Selections averaged 60 different word types, accounting for 27% of the different word types in mathematics overall. In total there were 561 different academic word types identified. The standard deviation for word tokens is relatively low, although variation in the number of different types across topics was higher, with the magnitude of the standard deviation approaching half the subject-area average. Just 38 of these words on average were identified as general academic words, with 24 of these identified as different word types. There is little variation in these numbers across topics.

There are slightly more specialized words in science selections than any other category of academic vocabulary. Such words include *anther, convection,* and *evaporation*. The number of different specialized academic word types is relatively modest at just 30 different word types accounting for 14% of all word types in science. Table 8 also shows that there is considerable variation across science topics in the average number of specialized academic words used and in the number of different types employed in the selections. The magnitude of the standard deviations is more than one third the value of the means, suggesting that some topics, such as *Plants,* contain far more specialized academic vocabulary than others. While the topics in the science subject area also include measurement words, colloquialisms, and proper nouns, these categories are rare, and the standard deviations are larger than the mean values, suggesting a large degree of heterogeneity across topics.

Table 8

Academic Vocabulary in Science by Topic [Percentage of Total Words in Brackets]

Statistic	Topic averages				Subject-area
	Matter	Plants	Storms	Water cycle	average (*SD*)
Total no. of all academic word tokens	153.33 [22.73]	166.33 [25.75]	99.33 [17.46]	105.33 [19.86]	130.83 (31.71) [21.45]
Total no. of all academic word types	63 [27.53]	71.33 [30.26]	51.33 [25.73]	54.33 [25.73]	60.00 (12.68) [26.69]
Total no. of general academic word tokens	51.33 [7.67]	36.33 [5.61]	29.33 [5.15]	33 [6.33]	37.50 (10.53) [6.19]
Total no. of general academic word types	29.67 [13.02]	24.33 [10.37]	20.33 [9.18]	23 [11.13]	24.33 (4.10) [10.93]
Total no. of specialized word tokens	87 [12.98]	129.33 [20.94]	53.67 [9.41]	67.67 [12.61]	84.42 (31.13) [13.83]
Total no. of specialized word types	26.33 [11.49]	46 [19.48]	21 [9.54]	29.67 [13.83]	30.75 (12.56) [13.58]
Total no. of measurement word tokens	13 [1.92]	0 [0]	9 [1.64]	1.33 [.24]	5.83 (7.47) [.95]
Total no. of measurement word types	6.33 [2.72]	0 [0]	3.33 [1.56]	.67 [.31]	2.58 (3.63) [1.15]
Total no. of colloquialism tokens[a]	.33 [.05]	.67 [.10]	1 [.17]	.67 [.12]	.58 (.89) [.10]
Total no. of colloquialism types[a]	.33 [.15]	.67 [.26]	1 [.43]	.67 [.28]	.67 (.89) [.28]
Total no. of proper noun tokens[a]	.67 [.11]	.33 [.05]	6.33 [1.09]	2.67 [.56]	2.5 (3.50) [.45]
Total no. of proper noun types[a]	.33 [.15]	.33 [.15]	5.67 [2.52]	.33 [.19]	1.67 (2.77) [.75]

[a]These subcategories are found in the selections and the words in them are not automatically considered specialized or general academic vocabulary but must meet the academic vocabulary definition provided above.Table 9

Academic Words in Social Studies by Topic [Percentage of Total Words in Brackets]

Statistic	Topic averages				Subject-area average (*SD*)
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of all academic word tokens	185 [29.97]	193 [19.51]	191.33 [25.75]	141.67 [19.83]	177.75 (39.67) [23.76]
Total no. of all academic word types	111 [30.13]	73.33 [19.60]	99.67 [25.92]	83 [19.83]	91.75 (30.67) [23.87]
Total no. of general academic word tokens	43 [5]	27.33 [3.05]	18.33 [2.12]	28.67 [3.04]	29.33 (17.73) [3.30]
Total no. of general academic word types	38.67 [10.47]	23 [6.06]	16 [4.17]	24 [5.75]	25.42 (15.69) [6.61]
Total no. of specialized word tokens	72.67 [8.55]	107 [12.02]	70 [7.87]	78.33 [7.99]	82.00 (19.48) [9.11]
Total no. of specialized word types	38.67 [10.47]	46.67 [12.57]	45 [11.68]	36.33 [8.67]	41.67 (11.56) [10.85]
Total no. of colloquialism tokens[a]	2.33 [.26]	1.33 [.15]	1.67 [.19]	.67 [.70]	3.00 (3.22) [.33]
Total no. of colloquialism types[a]	2.33 [.61]	1.33 [.36]	1.67 [.44]	6 [1.44]	2.83 (2.92) [.71]
Total no. of proper noun tokens[a]	66.33 [7.78]	56 [6.22]	100.67 [11.27]	27.33 [2.83]	62.58 (30.83) [7.03]
Total no. of proper noun types[a]	30.67 [8.42]	1 [.26]	36.33 [9.46]	16 [3.82]	21.00 (15.46) [5.49]

[a]These words are not automatically considered specialized or general academic vocabulary but must meet the academic vocabulary definition provided above. A very small number of measurement words (5 tokens) and instances of verbatim speech (5 tokens) appear in the text selections but not across all topic areas. These amounted to fewer than 1 word on average across topics.

Social Studies. The average number of words identified as academic vocabulary in the social studies selections is 178 or about 24% on average of the total number of words in the social studies subject area (see Table 9). There is an average of 92 different word types per topic, accounting for 24% of the different word types in social studies. In total there were 875 different academic word types identified. The standard deviations for word tokens and types are relatively low, suggesting little variation in the number of words and different words types across topics. On average, just 29, or 3%, of all words in social science selections were identified as general academic words, with 25 of these identified as different word types. Variation in these numbers across topics is relatively high, with the standard deviations in excess of half the mean values for both general academic word tokens and types. The topic *Pilgrims* has 18 general academic word tokens (16 different types) on average across selections, whereas *Declaration of Independence* contains 43 such words on average (39 different types).

Table 9 shows that there are far more specialized academic words (82) than general academic words in social studies on average, and these account for 9% of all word tokens and 10% of all word types in this subject area. Such words include *abolitionist*, *landowner*, and *merchant*. There is little variation in these numbers across topics. The topics in the social studies subject area also include colloquialisms and proper nouns. The former are rare, and the standard deviations are larger than the mean values, suggesting an enormous degree of idiosyncrasy across topics. Proper nouns are more prevalent with 63 word tokens on average (21 different word types), accounting for 7% of all word tokens in social studies.

Summary. Comparing across the three subjects, we see that mathematics selections contain fewer academic words as a proportion of all words in the subject area. Science and social studies have comparable percentages of academic words. Breaking the academic vocabulary down further into subcategories, we find that all subject areas have proportionately more specialized vocabulary than any other category of words. Mathematics also contains a relatively large number of measurement words that rival specialized words in both number and proportion of all words in the mathematics selections. Neither science nor social studies contain many words in other categories, with the exception of social studies containing a relatively high proportion of proper nouns, such as *Congress, Lowell,* and *Thomas Jefferson*. Few words were found in common across the three subject areas. Just 15 word types out of a possible 275 word types were found in the text selections across mathematics, science and social studies.[6] These words included nouns like *population* and *products*, the adjective *equal*, measurement words such as *pound* and *km*, verbs such as *continued, express, produce and suppose* and the phrase *in order to* (see Appendix B for full list).

Overall Word Frequency Counts and Low-Frequency Words

Word frequency is simply the number of times a word occurred in a text (i.e., the number of tokens or instances). For this study, low frequency is operationalized as less than or equal to 10 occurrences per million words in a published fifth-grade level lexical frequency corpus (Zeno et al., 1995).

Procedures

Using the FREQ option of CLAN, we generated word lists that provide the count of how frequently each unique word occurred (see Appendix C for word lists of the 20 most frequently used words in mathematics, science, and social studies selections). We examine these word frequency counts separately by subject, reporting the 20 most frequently occurring words, the proportion of all words for which these account, the proportion of all words for which the number of words occurring only once in a given subject matter accounts, and provide examples of these least used words in the text selections.

In further analyses, three researchers coded selections for words that met the low-frequency criterion based on the corpus used by Zeno et al. (1995). The total number of words that were identified as occurring with low frequency is provided for each of the topics across subjects. This number is also expressed as a percentage of all the words in the selections for each topic. In addition, we also report the total number of unique word types among these low-frequency lexical items, and provide the percentage of total word types these low-frequency words account for in each topic. Accuracy checks were periodically made on 12 selections (a third of the data) to ensure that the raters identified words as low frequency according to the reference corpus at a desired minimum of 95% correctly identified. Agreement between two researchers ranged from 91% to 100%, averaging 99%.

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[6] The greatest number of words that could overlap across the three subject areas is in fact the lowest number of academic words identified in any of the three subject areas—mathematics.

Findings

Mathematics. The most commonly used words (i.e., the 20 most used words in the mathematics selections) account for 2271 (34%) of the total words used in the mathematics selections overall. The definite determiner *the*, among the most commonly occurring words in the English language (see for example Francis & Kucera, 1982), accounts for 410 instances, almost twice as many tokens as the next most commonly used word—the preposition *of* with 258 tokens. Function words such as the indefinite determiner (i.e., *a*) and common prepositions (e.g., *to, in, for*), and common forms of the copula verb "to be" (e.g., *is*) account for frequency counts in the 100s. The remaining words in the top 20 count range from 83 tokens (*each*) to just 45 tokens (*if*), and include two personal pronouns (e.g., *he, she*) and words that are semantically related to quantity (e.g., *much, many*). There were 571 words (8%) that occurred just once in the mathematics selections. Many of these were irrelevant to the mathematics construct (i.e., names of fictitious or real people and places used to provide context for the word problems). A few others appear to be mathematics content words (e.g., *gain, mode, factor*), that, due to their infrequent use, may not be widely used at the fifth-grade level or pertain to topic areas not directly selected for analysis.

Overall, there are very few words coded as low-frequency status in any of the mathematics selections. Table 10 shows that on average such words only account for about 8% of the total word tokens in the mathematics selections. However, if these low-frequency words are unfamiliar to the reader, comprehending the text will pose a challenge. The standard deviations associated with the subject-area averages for types and tokens are moderate, suggesting little variation across the topics in mathematics.

Science. The most commonly used words (i.e., the 20 most used words in the science selections) account for 2544 (35%) of the total words used in the science selections overall. Again, the definite determiner *the* accounts for many (585) instances, more than twice as many tokens as the next most commonly used word, which was the indefinite determiner *a* with 244 tokens. Remaining counts ranged from 236 to 45. While many of the remaining words in the top 20 count are function words (e.g., *in, to, from*), the science selections also employed substantive or content words in high numbers such as *water* (144 tokens) and *mass* (45 tokens).[7] In addition, there are a number of different verb forms in high usage (e.g., *is, was, are, can*), variety in personal pronouns (e.g., *you, it*), a demonstrative pronoun (i.e., *this*), and high usage of the conjuncts *and* and *or*. There are 618 words (8.5%) that occurred just once in the science selections. Many appear to be science content words (e.g., *adaptive, capacity, organ*). However, due to their infrequent occurrence these words may be related to topics that were not directly selected for analysis or are not widely taught at the fifth-grade level.

[7] The use of *content words* stands in contrast with *function words* in the linguistic sense rather than to mean content words such as the subject-area specialized terminology of mathematics, science or social studies.

Table 10

Low Frequency Words in Three Subjects by Topic [Percentage of Total Words in Brackets]

Statistic	Mathematics averages (*SD*)				Subject-area average (*SD*)
	Decimals	Fractions	Multiplication	Ratios	
Total no. of low freq. Word tokens	44.33 (7.30)	49.67 (8.69)	39 (7.11)	47.67 (7.72)	45.17 (9.68) [7.70]
Total no. of low freq. Word types	31 (12.15)	32 (13.09)	26 (10.79)	29.33 (11.21)	29.58 (5.43) [11.81]
	Science averages (*SD*)				
	Matter	Plants	Storms	Water cycle	
Total no. of low freq. Word tokens	41 (6.09)	76 (11.84)	47.67 (8.31)	33.33 (6.24)	49.50 (21.16) [8.12]
Total no. of low freq. Word types	26.67 (11.61)	35.67 (15.23)	26.00 (11.69)	23.67 (11.07)	28 (7.76) [12.40]
	Social Studies averages (*SD*)				
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of low freq. Word tokens	62 (7.36)	79.67 (8.84)	73.67 (8.22)	91 (9.23)	76.58 (21.39) [8.42]
Total no. of low freq. Word types	44.33 (12.33)	47.33 (12.43)	39.67 (10.32)	55.67 (13.28)	46.75 (11.77) [12.01]

There is great variability in the use of low-frequency designated words across the topic selections for science as captured in the standard deviation of 21, almost half the value of the subject-area average. This is logical as words vary considerably according to topic and as words can be mentioned just once in an effort to exemplify a point (a common discourse-level feature we discuss in Chapter 5); such one-time usage is likely a hallmark of conceptually dense prose. Table 10 shows a 43-word difference between the number of low-frequency word tokens in *Water Cycle* selections and *Plant* selections. In terms of the percentage of all words these low-frequency lexical items account for, this varies from a low of 6% to a high of nearly 12%. It is interesting to note that while *Plants* has far more low-frequency words, it repeats these same words more often than the other topic areas.

Social Studies. The most commonly used words (i.e., the 20 most used words in the social studies selections) account for 3484 (32%) of the total words used in the social studies selections overall. Again, the definite determiner *the* accounts for many instances (857), nearly three times as many tokens as the next most commonly used word, the preposition *to* with 355 tokens. Remaining counts range from 286 to just 53. Many of these words are prepositions (e.g., *of, in, for, on, by, from*), personal or possessive pronominal forms (e.g., *they, he, their*), and the demonstrative pronoun *that*. The conjuncts *and* and *or* occur in the top 20 count. Just one substantive content word *people* is among the 20 most frequently used words (63 tokens). There are 966 words (9%) that occur just once in the social studies selections. Many of these are proper names for real people, places, and events. Others appear to be social studies content words (e.g., *articles, government, opinion*), that due to their infrequent use may not be widely used in social studies at the fifth-grade level or else they pertain to topic areas not directly selected for analyses.

There is some variability in the use of low-frequency words across the topic selections for social studies. The standard deviation at 21 is approximately a quarter of the value of the subject-area average. Table 10 shows a 29-word difference between the number of low-frequency words in *Slavery* selections and *Declaration of Independence* selections. The percentage of all words for which these low frequency lexical items account, remains relatively consistent at about 8% (+/- 1%).

Summary. Comparing across mathematics, science and social studies, we see that the most frequently used words account for just over 30% of all word tokens in each of the three subjects. The three subjects share seven words in common among the twenty most frequently used in each subject area. These are composed of the determiners *the* and *a*, the prepositions *of, to, in, on* and the conjunct *and*. There are differences, however, in the semantic composition of the twenty most frequent words across the three subject areas. Specifically there is greater variety in lexical usage and greater inclusion of content words alongside more commonly occurring function words in the science and social studies selections than in the mathematics selections.

We also see considerable variability in the textbook selections in the percentages of words that are designated as low-frequency words. Averages for mathematics and science are relatively similar with low-frequency words in both subject areas accounting for about 8% of the total word count for these subjects overall. Approximately 30 of these words are used at least once on average in both subjects, and this accounts for about 12% of all the word types in either mathematics or science.

However, whereas mathematics is extremely uniform across topics, one science topic area is exceedingly elevated in the number of low-frequency words compared to the other three topic areas. While social studies has about 50% more words identified as low frequency on average than the other two subjects in absolute terms, this raw number accounts for only a fraction of a percent of the total word count in social studies (less than 1 percent on average), as well as a fraction of the different word types in social studies (just over 1 percent on average). Like science, social studies also has one topic area that had many more low-frequency words than the other three topics. The research suggests the relatively minor numeric role of low-frequency words in the total word counts for all selections, but the relatively greater role of low-frequency words in terms of total number of different word types in mathematics and science.

Three-or-More-Syllable Words

Multisyllabic words are often more difficult and less common and have typically been used as an index of difficulty in readability measures (e.g. Flesch, 1948; Klare, 1974; Zakaluk & Samuels, 1988). The *American Heritage Dictionary* defines a syllable as "a unit of spoken language consisting of a single uninterrupted sound formed by a vowel, diphthong, or syllabic consonant alone, or by any of these sounds preceded, followed, or surrounded by one or more consonants" (4^{th} edition, 2000).

Procedures

Three researchers coded the selections. Proper nouns and abbreviations were included in the analyses, but numerals or symbols were not. During coding, we considered how many syllables abbreviations symbolized. Whenever researchers disagreed on the number of syllables in a given word, a dictionary was consulted. Accuracy checks were periodically made on one third of the data to ensure that the raters identified words with three or more syllables (according to the dictionary) at a desired minimum of 95% correctly identified. Agreement between two researchers ranged from 99.7% to 100%, averaging 99.9%.

The analyses provide the total number of words that were identified as multisyllabic words with three or more syllables for each of the topics across the subject- areas. The number of these words is also expressed as a percentage of all words in the topic selections. In addition, we also report the total number of unique word types among these 3-or-more syllable words and the percentage of total word types for which these account in each topic.

Findings

Mathematics. Very few words contain three or more syllables in mathematics (see Table 11). These words account for only 6% of all word tokens on average and for slightly more (9%) of all word types. There is some variation across topics with a 17-word difference from the highest to lowest amount of 3-or-more-syllable words contained in the text selections; the standard deviation of 13 is greater than a third of the value of the subject-area average for the number of word tokens.

Table 11

Three-or-More-Syllable Words in Three Subjects by Topic [Percentage of Total Words in Brackets]

Statistic	Mathematics averages (*SD*)				Subject-area average (*SD*)
	Decimals	Fractions	Multiplication	Ratios	
Total no. of ≥ 3 syllable word tokens	37 (6.16)	28.67 (5.18)	26.67 (4.81)	44 (7.12)	34.08 (13.39) [5.80]
Total no. of ≥ 3 syllable word types	26.67 (10.45)	19.67 (8.01)	20 (8.17)	24 (9.20)	22.58 (6.42) [8.95]
	Science averages (*SD*)				
	Matter	Plants	Storms	Water cycle	
Total no. of ≥ 3 syllable word tokens	61.67 (9.14)	62 (9.63)	64.33 (11.29)	43 (8.06)	57.75 (11.28) [9.53]
Total no. of ≥ 3 syllable word types	36 (15.75)	37.67 (16.05)	32.67 (14.71)	27 (12.58)	33.33 (7.24) [14.77]
	Social Studies averages (*SD*)				
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of ≥ 3 syllable word tokens	123.33 (14.55)	96.67 (10.72)	114.67 (12.79)	99.33 (10.08)	108.50 (17.75) [11.97]
Total no. of ≥ 3 syllable word types	64.33 (17.52)	54.00 (14.19)	65.67 (17.09)	65.00 (15.50)	62.25 (11.62) [16.13]

Science. Table 11 shows that 10% of words in the science selections are 3-or-more-syllable-words on average. One topic, namely the *Water Cycle*, has far fewer such words than the other three topic areas, which depresses the mean value to some degree. Otherwise, the variation across topics is not great (standard deviations are moderate in relation to the respective means). In terms of word types, three-or-more-syllable words account for about 15% of all word types on average.

Social Studies. Words with three or more syllables account for 12% of words in social studies text selections on average (see Table 11). There is a 27-word difference in the number of these multisyllabic words across topic areas. However, given the large number of multisyllabic words within each of the topics, this amount of variation is relatively small; the standard deviation at 18 is less than one-fifth the value of the overall average for number of tokens. Multisyllabic words account for about 16% of all word types in social studies.

Summary. When we compare the three subjects, we see that mathematics has far fewer multisyllabic words with 3 or more syllables than either science or social studies as a percentage of the total number of words in the selections. In social studies more than 16% of all word types are accounted for by words with three or more syllables on average. There is some variability across topics within all of the subject areas, although this is more a hallmark of mathematics than of science or social studies. Implications for test development suggest a relatively important role for three-or-more-syllable words in the word count of typical selections in science and social studies, but less so in the case of mathematics.

Derived Words

Derived words are formally and semantically more complex than their root forms and constitute much of the new vocabulary that native English-speaking students learn in the upper elementary grades (Anglin, 1993). Derived words are defined here as words that have changed grammatical category (part of speech) by adding an affix (typically a suffix such as *–ation*, *-ly*, *-ance*, *-ness*, *-ity*, etc.).

Procedures

Three researchers coded the selections by identifying a word and confirming its classification by examining the affix. It was imperative that each identified word could exist independently as a word without the affix. Included in the analyses were present and past participles functioning as modifiers as well as gerunds. However, we did not incorporate words that do not change grammatical category, nor did we include compound words, words with derivational relationships that may be direct or obscure, forms with no added morphology, or possessive forms. Reliability between coders was calculated using two selections from each of the three subject-areas. The number of derived words in these six selections ranged from 476 to 984. Simple agreement in rating these samples was .99 for both samples in mathematics and science, and .98 and .99 for the two selections respectively in social studies.

First the total number of words that were identified as morphologically derived from root forms is provided for each of the topics across the subjects. The number of derived words is also expressed as a percentage of words in the topic selections. In addition, we also report the total number of unique word types among these derived words and the percentage of total word types these account for in each topic.

Findings

Mathematics. Table 12 shows that there are very few derived words in the mathematics selections, although there is variation across topics; the standard deviation of 7 is large at half the value of the overall average. The *Ratios* topic has more derived words than the other three topics. On average, derived words account for just 2% of all word tokens and about 4% of all word types in mathematics.

Science. On average, 35 words in the science selections are derived from root forms and account for about 6% of all words in the science selections (see Table 12). These words account for about 11% of the total number of different word types on average. The standard deviations are moderate, suggesting the results are relatively uniform across the individual topic selections.

Social Studies. From Table 12, we see that the number of derived word tokens varies somewhat by topic with the standard deviation at 24 being greater than a third of the value of the overall subject-area average. There is a 45-word difference between the topic with the lowest number of derived words (*Pilgrims*) and the topic with the highest number (*Slavery*). On average, derived words account for 8% of all words in social science selections. Derived word types account for 12% of all word types in social studies on average.

Table 12

Derived Words in Three Subjects by Topic [Percentage of Total Words in Brackets]

Statistic	Mathematics averages (*SD*)				Subject-area average (*SD*)
	Decimals	Fractions	Multiplication	Ratios	
Total no. of derived word tokens	9.67 (2.62)	14.67 (2.71)	9.33 (1.68)	19.67 (3.18)	13.33 (7.10) [2.31]
Total no. of derived word types	7.67 (3.01)	10 (4.09)	6.33 (2.55)	15.33 (5.87)	9.83 (4.78) [3.88]
	Science averages (*SD*)				
	Matter	Plants	Storms	Water cycle	
Total no. of derived word tokens	38.33 (5.67)	39.67 (6.18)	30.67 (5.35)	31 (4.46)	34.92 (9.82) [5.76]
Total no. of derived word types	26.67 (11.66)	25.33 (10.86)	22.67 (10.19)	22.33 (10.53)	24.25 (5.33) [10.81]
	Social Studies averages (*SD*)				
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of derived word tokens	69.67 (8.31)	81.00 (9.10)	49.00 (5.47)	94.33 (9.57)	73.50 (24.13) [8.11]
Total no. of derived word types	42.33 (11.91)	51.33 (13.56)	39.67 (10.32)	56.00 (13.35)	47.33 (9.89) [12.26]

Summary. Comparing across the three subjects, we see that mathematics selections contain few derived words. Science and social studies have modest amounts more. Science is homogeneous across topics, whereas mathematics and social studies each have topic areas with differing numbers of derived words. These findings have implications for test development that suggest derived words play only a minor role in mathematics selections and slightly larger roles for the other two subject areas at the fifth-grade level. However, analysis of later grade levels may provide a different picture.

Comparison Across Lexical Analyses

The purpose of comparing the vocabulary lists generated in the analysis of academic vocabulary and the analyses of three key lexical features already examined informs how we can most effectively select words for test development purposes. If academic vocabulary can be predicted from one or a combination of the three key lexical features, we may more efficiently identify vocabulary for assessment than if we apply a more laborious and potentially subjective coding schema of academic language criteria.

Procedures

Using CLAN programs on combinations of word lists for academic vocabulary, low-frequency words, words with 3 or more syllables, and derived words, we calculated the number of academic word types that also appeared in the three lexical categories lists as, (a) a proportion of all words in the three lexical categories individually, and (b) as a proportion of all academic words. These were calculated separately for the three subject areas.

We then compared the four word lists for academic vocabulary, low-frequency words, 3-or-more syllable words, and derived words to tally the number of word types that occurred uniquely (i.e., no overlap across lists), occurred twice (i.e., overlapped 50% by appearing on two word lists only), occurred three times (i.e., overlapped 75% by appearing on three word lists only), and finally occurred four times (i.e., overlapped 100% by appearing on all four word lists). Again, we calculated this overlap in word lists separately by subject area.

Findings

Individual Predictions of Academic Vocabulary. Table 13 shows that in mathematics selections only 20% of low-frequency words at the fifth grade according to criterion by Zeno et al (1995) were also identified by raters as academic vocabulary. This percentage increases to just above 30% of 3-or-more-syllable words or derived words identified as academic vocabulary. In science and social studies, far more low-frequency words were identified as academic vocabulary than in mathematics. Similar results were obtained with 3-or-more-syllable words. A total of 81% of derived words in science were also identified as academic vocabulary. This percentage is only slightly lower in social studies.

Table 13

Proportion of Low Frequency Word, 3-or-More-Syllable-Word, and Derived Word Types Identified as Academic Word Types by Subject

Subject	Low freq.	3-or-more-syllables	Derived
Math	.20	.34	.33
Science	.61	.52	.81
Social Studies	.58	.54	.64

Next, looking at the number of words identified as low frequency, multisyllabic, or derived as proportions of all academic vocabulary identified, we see strong subject-area effects. Table 14 shows mathematics displaying less association between the academic English words identified and the words identified in the three other analyses.

Table 14

Proportion of Academic Vocabulary Accounted for by Low Frequency Word, 3-or-More-Syllable-Word, and Derived Word Types by Subject

	Low freq	3-or-more-syllables	Derived
Math	.11	.10	.16
Science	.23	.17	.28
Social Studies	.23	.20	.29

The three categories account for between 10-16% of all academic words only. Science and social studies pattern similarly, but account for larger proportions of academic vocabulary. Derived words in particular account for nearly 30% of all words that were identified as academic vocabulary. While this is promising for selecting a sizable number of words for test development purposes, it means of course that 70% of all words identified as academic in science and social studies may not be derived, and even fewer are identifiable as low frequency or consisting of 3 or more syllables.

Degree of Concordance Across Lexical Analyses. Another manner of looking at the degree of predictability of academic language from lexical features of words also suggests that we will miss many words identified as academic vocabulary if we rely on these analyses alone or even in combination. Table 15 shows that in mathematics texts the majority (72%) of word tokens identified as academic English vocabulary had none of the features of the three lexical analyses we also performed on words in the selections. Only 20% shared one other lexical feature we had analyzed, either low frequency, 3 or more syllables, or derived form. Even fewer shared two or more features, and just 1% of words identified as academic vocabulary in the mathematics selections overlapped with all three of the lexical features. Science and social studies fared somewhat better and again were very similar in pattern. Just over 50% of academic English words shared none of the three lexical features we also analyzed (conversely, approximately 45% showed at least one lexical feature), about 25% shared one feature, about 15% shared two, and 5% of the words shared all three lexical features.

Table 15

Number of Academic Words Appearing in Any Combination with Three Lexical Features by Subject

	No overlap	50% overlap (any 1 feature)	75% overlap (any 2 features)	100% overlap (any 3 features)
Math	468 [72]	129 [20]	40 [09]	9 [1]
Science	430 [56]	193 [25]	101 [13]	39 [5]
Social Studies	697 [55]	335 [26]	169 [15]	64 [5]

Note. Percentages may not sum to 1.0 due to rounding. [Percentage of Words Within Subject Area in Brackets]

Implications of these research findings for test development suggest that the vagaries of what makes a word "academic" (especially for mathematics) make it largely impossible to predict using combinations of lexical features or even one feature alone. Although, if we were forced to choose one such lexical feature, derived words would be the most promising for all three subjects, science and social studies in particular.

Additional Lexical Analyses

Two additional areas of analysis were included to complement the description of vocabulary usage in the text selections. While both the number and variety of clause connectors and the utilization of nominalizations were relatively few in these fifth-grade texts across all subjects, they are included here in the development of a comprehensive method for text analyses because of the potential for these features to be more elaborate in the texts of later grades.

Clause Connectors. We focused on two types of connectors in our analysis: adverbial dependent clause connectors (e.g., *because, when, if*) and coordinate clause connectors (e.g., *and, but, or, nor*). Adverbial clause connectors introduce a finite adverbial clause and signal the relationship between that clause and the rest of the sentence. Coordinate clause connectors, on the other hand, join two independent clauses occurring within a single sentence. Meaning relationships between clauses are frequently signaled by clause connectors, which occur frequently in written expository texts. Previous research suggests that students may not interpret adverbial clause connectors correctly and therefore misunderstand the meaning relationships they encode (e.g., Celce-Murcia & Larsen-Freeman, 1983; Halliday & Hasan, 1976).

Procedures

Adverbial dependent clause connectors were identified for each subject area (see Appendix D for a list of the clause connectors identified in the selections). For each adverbial dependent and coordinate clause connector, we calculated the raw frequency, and the percentage of the total number of words each constituted for the subject areas. For the adverbial dependent clause connectors we also calculated the rate of tokens and types per 100 sentences and per 1000 words.

Reliability was calculated by two researchers. Percentage of initial agreement is the percentage agreed upon independently, whereas consensus agreement is percentage agreed upon after discussion of discrepancies. The average percentage of initial agreement was 85.6%, and the interrater consensus agreement was 100%.

Findings

Mathematics. We identified a total of 7 adverbial clause connectors in the dependent clauses and an additional 4 connectors used in coordinate clauses (see Chapter 4 for a description of the total number and type of clauses). The frequency counts are a total of 56 instances for the dependent clause connectors and 24 for coordinate clause connectors. The most frequent adverbial clause connector is the connector *if* (70% of the total number of all adverbial connectors), followed by *when* (13%). Frequent coordinate clause connectors include *and* (50% of the total number of coordinate connectors) and *but* (42%).

Science. We identified 15 adverbial clause connectors used in dependent clauses and 2 connectors in the coordinate clauses. The frequency counts are 102 instances for the dependent clause connectors and 11 for the coordinate clause connectors. The most frequent adverbial connectors are *when* (27%), *because* (15%), *if* (10%), and *as* (27%). The only frequent coordinate connector is *and* (91%).

Social Studies. We identified 17 different adverbial clause connectors used in dependent clauses and 4 connectors in coordinate clauses. The frequency counts are a total of 78 instances for dependent clause connectors and 28 for coordinate clause connectors. The most frequent adverbial clause connectors are *when* (23%), *as* (19%) and *after* (12%). Frequent coordinate clause connectors include *but* (57%) and *and* (36%).

Table 16

Adverbial Dependent Clause Connectors in Three Subjects

Statistic	Math	Science	Social Studies
No. of tokens	56	101	78
No. of tokens per 100 sentences	8.56[a]	17.84	9.61
No. of tokens per 1000 words	7.99[b]	13.91	7.17
No. of types	7	15	17
No. of types per 100 sentences	1.07	2.65	2.09
No. of types per 1000 words	1.00	2.07	1.56

[a]To derive this number, we divide the number of word tokens (types) by the number of sentences identified in all math selections. We then multiply the number by 100 and round it to two decimal places. In this case, the number of word tokens is 56, and the number of sentences in math is 654: (54/654)*100=8.56

[b]To derive this number, we divide the number of word tokens (types) by the number of words identified in all math selections. We then multiply the number by 1000 and round it to two decimal places. In this case, the number of word tokens is 56, and the number of sentences in math is 7008: (56/7008)*1000=7.99

Summary. Using rate data to compare across subject areas, we see in Table 16 that science has more unique types of adverbial dependent clause connectors per 100 sentences and 1000 words than either mathematics or social studies. Science selections also employ adverbial dependent clause connectors far more often than either mathematics or social studies. Although to keep this in perspective even in science selections, this is only one adverbial clause connector every sixth sentence or every 72 words.

Taking both adverbial dependent clause connectors and coordinate clause connectors into consideration, we found that all three subject areas have some frequently occurring connectors in common, including: *and, when, if,* and *but*. The most frequent dependent clause connectors are *if* and *when*, whereas the most frequent coordinate clause connector is *and*.

Nominalizations. Nominalizations encode actions and processes (e.g., verb forms), states and notions (e.g., adjectives), or circumstances (e.g., adverbs) as nouns or noun phrases (e.g., *stratification, abstractness,* and *quickness*). They condense information within academic texts and thus increase the processing load for students (Gibbons, 1998; Martin, 1991; Schleppegrell, 2004). Nominalizations are utilized most frequently in academic and technical prose and are a hallmark of advanced literacy (Schleppegrell, 2004). Despite the relatively low frequency of nominalization in fifth-grade texts, the analysis is included for the purposes of developing a comprehensive method of text analyses for use in later grade levels.

Procedures

For each selection, we identified all the nominalizations and counted the number of tokens and types. We then calculated the proportion of nominalizations per selection as a percentage of the word tokens and types, the averages for each topic and subject area, and the rate of tokens and types per 100 sentences and per 1000 words. Reliability was calculated by two researchers independently. Initial agreement between two researchers ranged from 92.8% to 99.1%, and the consensus interrater agreement was 100%.

Findings

Mathematics. Table 17 provides the results of the analyses of nominalizations (e.g., *enlargement*) in mathematics. The average number of nominalizations is fairly small, with a range of 2 to 5 nominalizations identified per topic. There are only 2 unique nominalizations each in *Decimals*, *Fractions*, and *Multiplication*, and 4 in *Ratios*. Across topics, there is an average frequency of 4 nominalizations per selection, with an average number of 3 unique nominalizations. The average proportion of nominalization tokens and types per selection is less than 1% of tokens and types across topics.

Table 17

Use of Nominalizations in Three Subjects by Topic [Percentage of Total Words in Brackets]

Statistic	Mathematics averages				Subject-area average (*SD*)
	Decimals	Fractions	Multiplication	Ratios	
Total no. of nominalizations (tokens)	2 [0.33]	4 [0.76]	3 [0.59]	5 [0.83]	3.58 (2.84) [0.63]
Total no. of nominalizations (types)	2 [0.63]	2 [0.82]	2 [0.78]	4 [1.55]	2.42 (1.68) [0.95]
	Science averages				
	Matter	Plants	Storms	Water Cycle	
Total no. of nominalizations (tokens)	15 [0.02]	17 [2.60]	10 [1.65]	9 [1.84]	12.58 (7.03) [2.06]
Total no. of nominalizations (types)	9 [3.96]	9 [3.99]	6 [2.52]	6 [3.20]	7.58 (3.80) [3.42]
	Social Studies averages				
	Declaration of Independence	Industrial Revolution	Pilgrims	Slavery	
Total no. of nominalizations (tokens)	40 [4.74]	16 [1.74]	9 [1.03]	21 [2.12]	21.42 (12.62) [2.41]
Total no. of nominalizations (types)	17 [4.76]	8 [2.17]	7 [1.74]	11 [2.70]	10.92 (5.12) [2.84]

Science. Table 17 provides the data on nominalizations (e.g., *heaviness*) in science. On average, 13 nominalizations (tokens) were identified per selection across topics, with a range of 9 to 17 nominalizations per selection. There is a range of 6 to 9 unique nominalizations (types) in each selection per topic. Average percentages of both nominalization types and tokens in selections are small (2% and 3%, respectively), and variation across topics is minimal.

Social Studies. Table 17 also provides the data on nominalizations (e.g., *strengthened*) in social studies. An average of 21 nominalizations (tokens) and 11 unique types were identified per selection across topics. There is some variation across topics in the frequency of occurrence, ranging from 9 nominalizations (tokens) in *Pilgrims* to 40 in *Declaration of Independence*. There is a range of 7 to 17 unique types of nominalization per selection across topics. Overall, the average percentage of unique types of nominalization in selections is small (3% across topics), with most of the variation occurring in *Declaration of Independence*, which has the largest proportion of nominalizations.

Table 18

Nominalizations in Three Subjects

Statistic	Math	Science	Social Studies
No. of tokens	43	151	257
No. of tokens per 100 sentences	6.57	26.68	31.65
No. of tokens per 1000 words	6.14	20.80	23.63
No. of types	19	61	80
No. of types per 100 sentences	2.91	10.78	9.85
No. of types per 1000 words	2.71	8.40	7.35

Summary. Although there are very few nominalizations in the selections analyzed, there is some variation in the amount identified across the subject areas. Comparing the proportion of nominalizations across subjects, the average frequencies of nominalizations per selection are small (63% in mathematics, 2.06% in science, and 2.41% in social studies). There is more variation across topics in social studies than in mathematics and science. Using rate data to compare across subject areas, we see in Table 18 that science and social studies pattern similarly to one another in as much as they have far more nominalizations per 100 sentences and 1000 words than mathematics (approximately one nominalization every third sentence or every 48 words). Science and social studies text selections also have more unique types of nominalization than mathematics per 100 sentences and 1000 words.

Chapter Summary

In general, the mathematics texts we analyzed here seem quite different from both science and social studies texts; social studies texts seem the most complex in terms of the vocabulary identified with complex features (i.e., more demanding vocabulary). The findings are relatively uniform across topics within subject areas for most lexical features. Derivational forms of words identify academic vocabulary more systematically than any other lexical feature we examined here, especially so for the areas of science and social studies, at least at the fifth-grade level. There was highly repetitive use of a small set of non-academic words found across all three subject-areas (e.g., prepositions, determiners, and conjunctions). However, there were relatively few similarities in general academic vocabulary used across the subject-areas (just 15 academic words in common). Striking also is the infrequent use of general academic vocabulary relative to specialized academic vocabulary in any of the three subjects areas (e.g., just 3% of all word tokens in social studies are general academic words compared with 9% for specialized academic words). This is in contrast with the tertiary education level findings reported in Nation (2001) that suggest general academic words are used more frequently than specialized words. It is possible that the inconsistencies in results are due to developmental differences whereby far more words are considered specialized academic words due to the more encompassing "generalist" nature of the subject areas at the elementary school level than at the college level.[8]

[8] However, in more recent work, Chung and Nation (2003) coded tertiary level texts much as we coded the fifth-grade texts here and found that specialized words accounted for as much as 31% of all words in technical fields such as anatomy and 21% of all words in specialty fields such as applied linguistics (general academic vocabulary was identified by the Academic Word List [Coxhead, 2000] and accounted for 4% and 7% of words in these texts, respectively).

CHAPTER 4:

GRAMMATICAL ANALYSES

An important component of the profiles created for test development is the characterization of grammatical features of the texts. Thus, grammatical analyses were performed on the selections for the purpose of providing basic descriptive information for the text profiles. The analyses selected reflect multiple considerations, including the need to describe, at the most basic level, the sentence types in a particular subject area as well as the features that may differ according to grade level or subject area. We investigated the following grammatical features: (a) sentence types (e.g., simple, compound, complex, and compound/complex), (b) dependent clauses, (c) passive constructions, (d) prepositional phrases, (e) noun phrases, and (f) participial modifiers. While this is not an exhaustive list of grammatical features, some of them represent known sources of reading difficulty for English learners (e.g., Celce-Murcia and Larsen-Freeman, 1983) and may also help to characterize academic texts (e.g., Schleppegrell, 2001, 2004); if so, they should be taken into consideration in creating tests of academic text comprehension. A discussion of the analyses for each of the features follows in turn below.

Sentence Types and Clauses

The range of sentence types and the complexity of clausal structures may contribute to increases in the reading difficulty of academic texts for students as they progress through the grades. Thus, our goal in the current research is to gather data that helps characterize fifth-grade texts across the three subjects and also to ascertain what features of textbook language are most critical for students at this grade level. Ultimately these data will be compared to similar data across grade levels to identify changes in grammatical features as the language of textbooks becomes more complex.

Procedures

We classified sentences into four categories: simple, compound, complex, and compound/complex. A simple sentence contains one independent clause (e.g., *The* *ice on the river melts quickly under the warm sun*.).[9] A compound sentence contains two or more independent clauses joined by a conjunction (e.g., *and, but*) or a punctuation mark (e.g., semicolon, colon). The following sentence is an example of a compound sentence joined by the conjunction *but*: *Some deserts are very hot in the daytime, but temperatures can drop below freezing at night*. After the first independent clause in a sentence, all subsequent independent clauses were counted as coordinate clauses. A complex sentence contains one or more dependent clauses (typically defined as clauses that cannot stand alone) in addition to an independent (i.e., main) clause (e.g., *Although human beings don't notice the noises of nature, a lot of animals react to the sounds around them.*). A compound/complex sentence contains one or more dependent clauses and two or more independent clauses (e.g., *Washington soon realized that the Nation was not functioning well, so he became an advocate in the movement leading to the Constitutional Convention*.). For the purposes of this study, we identified the following as instances of dependent clauses: relative (adjectival) clauses (e.g., *The number <u>that he found</u> was less than 10.*); adverbial clauses of time, circumstance, manner, purpose, and condition (e.g., *He counted them <u>as he put them away</u>.*); and clausal structures functioning as subject, object, predicate nominal, or object of preposition (e.g., *He wrote about <u>how they had survived</u>.*).[10]

Next we calculated the percentage of the total number of sentences in each selection that fell into each of the four categories. We also counted the number of dependent clauses and the number of coordinate clauses. To determine the total number of clauses for the selection, we added the number of dependent clauses, coordinate clauses, and sentences (i.e., main clauses). We then calculated the percentage of total clauses that were dependent and the percentage that were coordinate. In addition, for all sentence and clause types, we calculated the average, range, and standard deviation at the topic and subject area levels.

Accuracy checks were performed at intervals on a total of 15% of the data analyzed to assure consistency in ratings, with a target accuracy rate of 90%. The overall accuracy rate across subject areas for rating dependent clauses was 86%, with a range of 66% to 95.5% within subjects. Interrater agreement for mathematics was low, initially in the range of 67% to 82%, so an additional check was performed

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[9] Examples were created by the authors to model the features identified in the textbook selections, unless otherwise indicated.

[10] Since the English language contains a continuum of structures from lexical to fully clausal, principled distinctions between clausal structures and phrases are not always obvious.

during the analyses, resulting in average agreement for mathematics of 80%, with a range of 66% to 92%. The results of the analyses follow below.

Findings

The results of the sentence and clause type analyses are presented by subject (mathematics, science, and social studies), followed by a summary of the findings across subject areas. Where relevant, variation at the topic level is discussed. (Appendices E and F provide topic level data for sentence and clause types, including aggregate counts and averages for topics within each content area.)

Mathematics. Tables 19 and 20 provide the number and percent of types of sentences and clauses in the mathematics selections.

Table 19

Sentence Types in Mathematics Selections

	Total Number	% of Total
Simple	531	81.19
Complex	111	16.97
Compound	10	1.53
Compound/complex	2	.31
Total	654	100.00

Table 20

Clause Types in Mathematics Selections

	Total Number	% of Total
Main clauses	654	71.71
Dependent clauses	242	26.54
Co-ordinate clauses	16	1.75
Total	912	100.00

Simple sentences comprise the majority of all sentences in mathematics. Specifically, 81% are simple sentences; 17% are complex sentences; 2% are compound sentences; and less than 1% are compound/complex sentences. Among all the clauses identified, approximately 26% are dependent clauses and only 2% are coordinate clauses.

Science. Tables 21 and 22 provide the number of sentences and clauses in the science selections.

Table 21

Sentence Types in Science Selections

	Total Number	% of Total
Simple	351	62.01
Complex	200	35.34
Compound	10	1.77
Compound/complex	5	.88
Total	566	100.00

Table 22

Clause Types in Science Selections

	Total Number	% of Total
Main clauses	566	58.69
Dependent clauses	242	29.37
Co-ordinate clauses	16	1.94
Total	824	100.00

As in mathematics, the majority of sentences in science are simple sentences (62%), followed by complex (35%). Compound and compound/complex sentences constitute only 2% and 1% of all sentences, respectively. Across topics, there is slight variation in the distribution of simple sentences, with the average percentages of simple sentences ranging from 58% to 68%.

Social Studies. Tables 23 and 24 provide the sentence type and clause data for social studies.

Table 23

Sentence Types in Social Studies Selections

	Total Number	% of Total
Simple	518	64.02
Complex	258	31.89
Compound	23	2.84
Compound/complex	10	1.24
Total	809	100.00

Table 24

Clause Types in Social Studies Selections

	Total Number	% of Total
Main clauses	812	68.41
Dependent clauses	339	28.56
Co-ordinate clauses	36	3.03
All clause types	1187	100.00

Again, as with mathematics and science, simple sentences make up the majority of sentences in social studies: 64% are simple sentences, 32% are complex sentences, 3% are compound sentences, and 1% are compound/complex sentences. The distribution of simple sentences varies slightly by topic, with the percentage of simple sentences as a proportion of all sentences ranging from 48% to 71%.[11] The mean number of clauses across topics in science is 99; approximately 28% are

[11] One topic contained many more complex sentences than the other three topics (*Declaration of Independence* contains an almost identical number of simple [48.41%] and complex sentences [46.81%]), indicating that there may be some variability according to topic in terms of sentence complexity. (Appendices E and F provide topic level data for sentence and clause types, including aggregate counts and averages for topics within each content area.)

dependent clauses and 3% are coordinate clauses, with variation in the average number of dependent clauses across topics.[12]

Summary. The data show that across the three subjects at the fifth-grade level the majority of sentences for the selections analyzed are simple, with a mean of 81% of all sentences in mathematics being simple sentences, 62% in science, and 64% in social studies. Seventeen percent of all sentences in mathematics, 35% in science, and 32% in social studies are complex sentences. Compound and compound/complex sentences constitute only a small proportion in all subjects, ranging from 0 to 3% per selection on average.

There is some variation in the composition of sentence types across subjects. The ratio of simple to complex sentences is nearly 5:1 in the mathematics selections, but it is less than 2:1 in science and social studies. Additionally, there are slightly more compound and compound/complex sentences in social studies than in mathematics and science, although the proportions of both sentence types are small overall.

Across subject areas, there are many more dependent clauses than coordinate clauses. The distribution of both clause types is fairly uniform across topics in all three subjects. The mean proportion of dependent clauses as a percentage of total clauses ranges from 27% to 29%, while the proportion of coordinate clauses is only 2% to 3%.

Use of Passive Verb Forms

The use of passive voice verb forms in textbooks is typically thought to contribute to reading difficulty, especially for English learners who may not have comparable constructions in their own first languages (Celce-Murcia & Larsen-Freeman, 1983). Passive voice verb forms occur less frequently than their active counterparts in English (Biber, 1988). To create an empirical basis for comparisons across grade levels and subject areas, we noted the frequency of passive verb forms. Specifically, we noted the frequency of two types of passives, those including the agent in a "by" phrase (e.g., *Water is absorbed <u>by the ground</u> and becomes groundwater*.), and those without an overt agent (e.g., *Large icebergs are found at the ice shelves of Antarctica.*) Because passives without an agent appear more frequently in both

[12] Specifically, the mean number of dependent clauses across topics ranged from 22 in *Industrial Revolution* to 39 in *Declaration of Independence*.

speech and writing in English (Shintani, 1979), we wanted to determine if this bias for agentless passive is identifiable in fifth-grade texts.

Procedures

We identified the passive voice verb forms in all selections and calculated the number per 100 sentences and per 1000 words. We then noted the number of passives that include a "by" phrase and calculated the mean number per 100 sentences and per 1000 words.

Accuracy checks were carried out at intervals throughout the analyses on a total of 15% of the data coded, with a target agreement rate of 90% or higher. Mean overall agreement was 90%, with a range of 75% to 100% within subjects. The results of the analyses are presented below.

Findings

The results of the analyses of passive voice verb forms are presented by subject area, followed by a summary comparing the results across subjects. Table 25 provides the number of passives in mathematics, science, and social studies selections.

Table 25

Passive Verb Forms in Three Subjects

	Number	No. per 100 Sentences	No. per 1000 Words
Mathematics			
All passives	28	4	4
Passives with "by" phrases	0	0	0
Science			
All passives	134	24	18.5
Passives with "by" phrases	19	3	2.6
Social Studies			
All passives	131	16	12.0
Passives with "by" phrases	13	2	1.2

Passive voice verb forms appear infrequently in the mathematics selections analyzed, with 4 passives per 100 sentences and 4 passives per 1000 words. In other words, a passive is used once every 25th sentence or every 250 words on average. No passives with "by" phrases were found in the mathematics selections.

In the fifth grade science textbooks analyzed in this study, passive voice verb forms occur more frequently than in mathematics, with an average of 24 occurrences per 100 sentences, and 19 occurrences per 1000 words. That is, every fourth sentence contains a passive or every 54 words on average. Only 14% of the passives included "by" phrases.[13]

In social studies selections, passive voice verb forms occurred 16 times per 100 sentences on average, and 12 times per 1000 words. On average, one passive is used in every sixth sentence or in every 83 words. Ten percent of the passives included "by" phrases.[14]

Summary. The number of passive voice verb forms in the selections analyzed for this research varies. Mathematics selections contain the least, with an average of 4 passives per 1000 words; science has the most, with 19 per 1000 words, and social studies has 12 per 1000 words. No passive voice verb forms with "by" phrases were identified in the mathematics selections; very few were identified in science (3 per 100 sentences) and social studies (2 per 100 sentences). The small number of passives identified in mathematics compared to science and social studies may be a function of the type of text analyzed, since mathematics selections are composed of numerous short word problems while science and social studies selections are extended texts. Our research indicates that passive voice verb forms are more prevalent in fifth-grade texts in science and social studies than in mathematics, but the overall frequency in those two subject areas is not great. The predominant form across subjects is the agentless passive; passives containing "by" phrases are infrequent at this grade level.

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13 While our focus here is on the data aggregated by the subject area, we note that there is some variability across topics in science. The topic *Storms* contains fewer passive voice verb forms than any other topic (an average number of 6 passive voice verb forms per selection as opposed to the highest topic average of 14.33 in *Matter*). There were no "by" phrases in *Matter* and *Storms* topic selections (see Appendix G for topic averages for passives in the three subject areas).

14 The topic *Pilgrims* has the largest proportion of passive voice verb forms, containing "by" (7 out of 26, or 27%), with the other three topics containing less than 10% each.

Prepositional Phrases

Prepositional phrases contribute to the length and complexity of sentences. A prepositional phrase consists of a preposition followed by a noun phrase, as in the sentence: *Our planet looks like a beautiful big blue marble [from a distance*.] In the current research, we investigated the frequency and length of prepositional phrases to determine typical usage in fifth-grade textbooks. This information will help us develop specific test specification guidelines for testing student ability to understand prepositional phrases of average length for a given content area.

Procedures

For each selection, we identified and counted the prepositional phrases, and we calculated the average number per 100 sentences and per 1000 words. We calculated the number of words in prepositional phrases, the mean, the range, and the standard deviation.

Interrater reliability was calculated at intervals throughout the analyses on a total of 15% of the data coded, with a target agreement rate of 90%. Across subjects, overall average agreement was 91%, with a range of 85% to 96%.

Findings

The results of the analyses of prepositional phrases in the text selections are presented below by subject area, followed by a summary in which the results are compared across subjects. Table 26 provides the data for prepositional phrases in the mathematics, science, and social studies selections.

The mathematics selections contained 716 prepositional phrases, for an average of 110 per 100 sentences and 102 per 1000 words. In other words, prepositional phrases occur in every sentence and once in every 10 words on average. Of the total number of words in the math selections, 37% are in prepositional phrases.[15] The mean number of words per prepositional phrase is 3.58; the range is 2-14, and the standard deviation for individual selections ranges from .82 to 1.86.

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[15] The topic *Ratios* contains a far higher percentage of words in prepositional phrases (51%) than the other three topics, which contain 29%, 31%, and 35% respectively (see Appendix H for topic averages for prepositional phrases in the three subject areas).

Table 26

Prepositional Phrases in Three Subjects

	Number	No. per 100 Sentences	No. per 1000 Words
Mathematics			
Prepositional phrases	716	109.5	102.2
Words in prepositional phrases	2601	397.7	371.1
Science			
Prepositional phrases	784	138.5	108.0
Words in prepositional phrases	3185	562.7	438.6
Social Studies			
Prepositional phrases	1167	143.7	107.3
Words in prepositional phrases	4367	537.8	401.5

The science selections contain 784 prepositional phrases, an average of 139 per 100 sentences and 108 per 1000 words. That is, on average such phrases occur more than once per sentence and once in every 9 words. Forty-four percent of all words in the science selections are in prepositional phrases. The mean number of words per prepositional phrase is 4.09; the range is 2-17, and the standard deviation for individual selections ranges from 1.51 to 3.90.

There were 1167 prepositional phrases in social studies selections, an average of 144 per 100 sentences and 107 per 1000 words. In other words, prepositional phrases occur nearly twice in a single sentence and once in every 9 words on average. Forty percent of the words in the selections are contained in prepositional phrases. The mean number of words per prepositional phrase is 3.74, with a range of 2-20 and a standard deviation for individual selections ranging from 1.69 to 2.77.

Summary. The average number of prepositional phrases per 1000 words is similar across content areas, ranging from 102 for mathematics to 107 for social studies and 108 for science. Of the total number of words in the content area selections, social studies has the greatest percentage, 44%, in prepositional phrases. The mean number of words per prepositional phrase is similar across content areas, with 3.6 for mathematics and 3.7 for social studies, and slightly higher, 4.0, for science. Social Studies and science selections contain the most prepositional phrases per 100 sentences (144 and 139, respectively); mathematics contains only 110 per 100 sentences.

Noun Phrases

A noun phrase consists of a noun plus its modifiers, either before (e.g., *a large, spiraling storm system*) or after (*e.g., water inside the tube; various components that make up our globe*) the noun. Long noun phrases may contribute to difficulty in academic texts (Halliday and Martin, 1993). However, little is known about the incidence or length of noun phrases from grade level to grade level or from one content area to another. To investigate, we looked at the frequency and length of noun phrases in each selection, as described below.

Procedures

First, we identified and counted the number of noun phrases in each selection. Then we calculated the average number per 100 sentences and per 1000 words. Finally, we counted the number of words in noun phrases, the mean, the range, and the standard deviation.[16]

As with the other analyses, reliability was calculated on approximately 15% of the samples rated with a target of 90% agreement. Across subjects, the average rate of agreement was 94%, with a range of 91% to 98%.

Findings

The results of the analyses of noun phrases are presented by subject below, followed by a summary in which the results are compared across subjects. Table 27 provides the noun phrase data for the mathematics, science, and social studies selections.

Mathematics selections contain 2031 noun phrases, with an average of 311 per 100 sentences and 290 per 1000 words. That is, there are 3 noun phrases in every sentence or one in every 3 words on average. Words in noun phrases are 69% of the total sample. The noun phrases range in length from 1 to 16 words across topics, with a mean length of 2 words; for individual selections, the standard deviations range from 1.01 to 2.56 (see Appendix I for topic averages for noun phrases in the three subjects).

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[16] To avoid inflating our noun phrase count, we did not count constituent noun phrases separately; *water inside the tube* was counted as 1 noun phrase containing 4 words.

Table 27

Noun Phrases in Three Subjects

	Number	No. per 100 Sentences	No. per 1000 Words
Mathematics			
Noun phrases	2031	310.6	289.8
Words in noun phrases	4839	740.0	690.5
Science			
Noun phrases	1633	288.5	224.9
Words in noun phrases	4809	849.6	662.3
Social Studies			
Noun phrases	2619	322.5	240.8
Words in noun phrases	7043	867.4	647.5

We found 1633 noun phrases in science selections, with 289 per 100 sentences and 225 per 1000 words. In other words, 3 noun phrases occur in every sentence or one occurs once in every 4 words on average. Of the total number of words in science selections, 66% occur in noun phrases. The noun phrases range in length from 1 to 23 words across topics, with a mean length of 3 words; standard deviations for individual selections range from 1.87 to 3.42.

There are 2619 noun phrases in social studies selections, with 323 per 100 sentences and 241 per 1000 words. The number of words in noun phrases as a percentage of total number of words is 65%. Noun phrases range in length from 1 to 19 words across topics, with a mean length of 3 words. Standard deviations for individual selections range from 1.77 to 2.79. These phrases also occur 3 times in every sentence or once in every 4 words on average.

Summary. Noun phrases range in length from a mean of 2.4 words in mathematics to 2.7 in social studies and 2.9 words in science. Although the mathematics texts contain the shortest noun phrases on average, they contain the most noun phrases per 1000 words (290) and the highest percentage of words in noun phrases (69%).

Participial Modifiers

Participial modifiers employ verb forms to modify nouns, contributing to syntactic complexity and a higher number of propositions in noun phrases. As with other grammatical features investigated in this research, little empirical evidence exists to indicate at which grade level participial modifiers may begin to play a more prominent role in student texts and whether there are subject area differences in usage.

A participial modifier is defined here as a participial verb form used to modify a noun. For example, in the sentence "*The number of enslaved people in the colonies reached 12,000,*" *enslaved* is a pre-nominal past participle. In the sentence "*Read the following excerpt*," the word *following* functions as a pre-nominal present participle. Examples of sentences with post-nominal participles include: 1) *The planters owned over half of the people <u>held</u> in slavery* (post-nominal past participle), and 2) *The number <u>surviving</u> was very small* (post-nominal present participle). Similar in function to a nonrestrictive relative clause, a nonrestrictive participial modifier may precede or follow the noun it modifies (e.g., *The fugitives, <u>frightened</u> by the noise, fled*.)

Procedures

In each selection, we first identified and classified participial modifiers as past or present participles. Each set was further classified into three categories: pre-nominal, post-nominal, or non-restrictive. We then calculated the frequency of participial modifiers in general, as well as the frequencies of each type and sub-type. For each type and sub-type, we calculated the average frequency per sentence and the frequency as a percentage of the total number of words in the selection. Next we calculated the average number per 100 sentences and per 1000 words. Finally, we calculated the mean, standard deviation, range, and the subject area totals and averages.

Accuracy checks were carried out at intervals throughout the analyses on a total of 15% of the data coded, with a target accuracy rate of 90%. The average overall accuracy rate was 94%, with a range of 83% to 100% across subjects. The results of the analyses are presented below.

Findings

Although we conducted a detailed analysis of participial modifiers, the numbers on average per selection are so small that the totals for all types and sub-types of modifiers are collapsed and presented in this report. Thus, the totals for present and past participial modifiers each represent the sum of the present and past pre-nominal, post-nominal, and nonrestrictive participial modifiers. Table 28 provides the participial modifier data for mathematics, science, and social studies selections.

Table 28

Participial Modifiers in Three Subjects

	Number	No. per 100 Sentences	No. per 1000 Words
Mathematics			
Present participial modifiers	7	1.07	1.00
Past participial modifiers	12	1.83	1.71
Total	19	2.9	2.71
Science			
Present participial modifiers	39	6.89	5.37
Past participial modifiers	53	9.36	7.29
Total	92	16.25	12.67
Social Studies			
Present participial modifiers	52	6.65	4.78
Past participial modifiers	89	10.96	8.18
Total	141	17.36	12.93

The total number of participial modifiers in all mathematics selections is 19. Present participial modifiers occur only once per 100 sentences or per 1000 words, on average; past participial modifiers occur at the rate of just under 2, on average. The area averages and the topic averages for frequency and percentage data are too small to warrant individual interpretation (see Appendix J for all subject areas).

There were 92 participial modifiers in the science selections; about 58% of them were past participles, occurring 9 times per 100 sentences and 7 times per 1000 words. That is, there is one modifier in every 11 sentences or in every 137 words, on average. The present participles were slightly less frequent.

Of the 141 participial modifiers in social studies selections, 89 are past participles constituting about 63% of the total. There are about 11 past participles per 100 sentences, and 8 per 1000 words; That is, on average there is one such modifier in every 9 sentences or in every 122 words. The averages for present participles are 7 and 5, respectively, or one modifier in every 15 sentences or every 209 words on average.

Summary. There is a discrepancy between mathematics and the other content areas in the frequency of participial modifiers. The average number of participial modifiers per 1000 words is 13 in science and social studies texts, but only 3 in mathematics texts. There are more pre-nominal than post-nominal participial modifiers in science and social studies selections; in mathematics selections the number of post-nominal modifiers is greater, but the total number of participials is lower. The actual numbers of these structures is low in all three content areas at this grade level compared to, for example, prepositional phrase modifiers. If further investigation shows participial modifiers to be a more salient feature of secondary school academic texts, the data here will provide a basis for comparison with texts at higher grade levels.

Chapter Summary

The majority of sentences across all three subject areas were simple sentences followed by a smaller number of complex sentences. Mathematics texts contained the highest percentage of simple sentences. There were very few complex syntactic constructions such as use of passive voice verb forms and participial modifiers in any of the text selections, although compared with mathematics texts, texts in science and social studies contained more of these grammatical features. All three subject areas had comparable numbers of prepositional phrases and noun phrases. On average 1 and 3 per sentence, respectively.

CHAPTER 5:

ORGANIZATION OF DISCOURSE

Discourse can be analyzed on multiple levels. In prior research, discourse has been analyzed according to (a) language functions used in conversations (e.g., Halliday, 1973; Halliday & Hasan, 1976; Short, 1993), (b) language functions used in classroom discourse and in texts (e.g., Chamot & O'Malley, 1994; Kinsella, 1997; Stevens et al., 2000; Bailey et al., 2004; Butler et al., 2004), and (c) ways text structures convey different types of information (e.g., Short, 1993; Vacca & Vacca, 1996). In the current analyses, we drew from Vacca and Vacca (1996), analyzing the organizational features of text at three levels of subordination, recognizing that there may be finer distinctions to be made within and among these levels. Our intention was to capture the author's purpose for writing, as well as to characterize the author's presentation of main ideas and use of supporting details.

The first level we analyzed is the overall organizational structure of each text selection, which is linked to the author's purpose for writing—referred to here as rhetorical mode.[17] Examples of rhetorical mode include *exposition* and *persuasion*. The second level of analysis was focused on the identification of dominant text feature(s), which are linked to the presentation of main ideas. Dominant features occur throughout a text, usually in support of the main idea (e.g., explaining the process of osmosis, which would be coded as *explanation*, or describing the cultural traits of an ancient culture, which would be coded as *description*). Examples of other dominant text features include *classification* and *sequencing*. The third level of analysis consisted of the identification of supporting features, which are typically used to provide key details and to establish relationships between main ideas in a selection. Supporting features are often embedded in prose that has a different dominant feature (e.g., in explaining the process of osmosis, the author may use examples, which would be coded as *exemplification*; while describing the cultural traits of an ancient culture, new terms may be defined, which would be coded as *definition*). Other examples of supporting features include *labeling* and *paraphrase*.

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[17] For the purpose of this research, we are using the term *rhetorical mode*, but we acknowledge that there are a variety of terms used across the disciplines, including discourse mode, macro-structure, and genre-schema (Richards, Platt, & Platt, 1992), that all refer to essentially the same concept.

For mathematics, we examined only the dominant and supporting text feature(s), since the selections consist of word problems, which do not have a rhetorical mode per se—a feature of extended discourse. We examined rhetorical mode and the dominant and supporting text features in the science and social studies selections.

Also, when applicable, we analyzed tasks in the mathematics word problems that require language output in addition to computation. Each word problem concludes with a problem statement or question, which we refer to in this report as a task. Some tasks require computation, while others require language production (e.g., explaining an answer or generating a problem question).

In addition to describing the rhetorical mode and dominant and supporting features in the selections, we characterized the overall frequency of their occurrence. To determine the frequency of occurrence of each rhetorical mode and dominant feature identified, we counted the number of selections in which a given rhetorical mode and/or dominant feature occurred. For supporting features, in addition to counting the number of selections in which a feature occurred, we noted if the features occurred just once in a selection or if there were multiple occurrences. Knowing whether or not there are multiple occurrences in each selection indicates how prevalent the features are within each text. Having both pieces of information (i.e., the frequency in which the features occur across as well as within texts) provides a stronger gauge of the relative frequency of each feature in the subject area.

Last, we identified the types of contexts in which the supporting features occurred (e.g., within a single sentence, across multiple sentences, or at the paragraph level). Knowing the linguistic contexts in which these features typically occur is important because it provides information needed for the development of item and task specifications (e.g., students should be tested on their ability to use and recognize linguistic features in text settings typical of each feature). We did not perform the same analysis for rhetorical mode and dominant features since by definition they occur across multiple linguistic contexts.

In the sections below, we first describe the procedures for the analyses. We then present the results and end the chapter with a discussion of the findings across the three subject areas.

Procedures

After we developed and refined the approach to analyzing the text selections, we established an initial glossary of organizational features with definitions and examples based on the definitions in Butler et al. (2004), which was then used as a coding schema. The glossary was expanded and refined through several rounds of rating sample texts from each subject area (see Appendix K for a complete glossary of features identified in the research). Later, new features were added as they were identified during the actual analyses.

In preparation for performing the analyses, we first divided the 12 selections for each subject area into 4 sets of 3 for the purpose of conducting reliability checks at regular intervals (see Chapter 1 for a description of the text selection process and the types of texts selected). Working independently, we read and identified the rhetorical mode in the science and social studies selections. Then we read the selections from all three subject areas and identified the text features in each selection, noting them in the margins next to each occurrence. We recorded and classified each feature as either a dominant feature or a supporting feature on a separate rating sheet. For supporting features, we indicated on the rating sheet whether the features occurred once or multiple times in a given selection and noted the types of contexts in which they occurred (e.g., at the sentence and/or paragraph level). A final reading of each selection served as a check to assure the completeness of the identifications and the accuracy of the classification of features into the dominant and supporting feature categories. In addition, for mathematics, features of the tasks that involve language production were specified when applicable.

Interrater reliability was calculated for the identification of rhetorical mode and text features, as well as for the classification of each feature as dominant or supporting. Two researchers rated five selections each from mathematics, science, and social studies, for a total of 15 out of the 36 selections; one researcher rated the other 21 selections. The reliability coefficients are provided in Table 29.

The average reliability for the identification of rhetorical mode and dominant and supporting text features in the 15 text selections rated by both researchers was .92 overall across subjects, with a range of .75 to 1.00 across individual text selections; reliability was .93 overall for the classification of features into the dominant and supporting categories across subjects, with a range of .88 to 1.00 across individual text selections.

Table 29

Reliability Coefficients by Subject

Subject	Identification of Rhetorical Mode & Text Features	Classification of Dominant & Supporting Features
Mathematics (5)	.95	1.00
Science (5)	1.00	.95
Social Studies (5)	.88	.90
Overall reliability (15)	.92	.93

Note. Numbers in parentheses indicate the number of text selections rated for a given subject.

Findings

In this section, we first discuss our findings in terms of the features identified in the selections and their overall frequency across selections by subject. We then discuss the frequency of the supporting features within the selections as well as the linguistic contexts in which these features occur.

Mathematics. As mentioned earlier, analysis of the rhetorical mode was not applicable to the mathematics text selections. A discussion of the dominant and supporting features and the features of the mathematics tasks is included here. Table 30 provides a list of the dominant and supporting features identified in the text selections and the number of selections in which each feature occurred.

Two types of dominant features were identified: *description* and *scenario*. In the selections analyzed in this study, the word problems are usually composed of scenarios in which a real-life situation is described (e.g., the word problem set up), followed by a task. Students use the descriptive information provided in the scenario to perform calculations needed to solve the problem. All 12 mathematics text selections contain word problems with scenarios, while six selections also contain word problems that consist of descriptions of a mathematical nature (e.g., *A fraction has a numerator of 9 and a denominator that is a prime number greater than 5. Why is such a fraction in its simplest form?*). Examples such as these were coded as descriptions rather than scenarios.

Table 30

Organizational Features in Fifth-Grade Mathematics Textbook Selections

Features	Dominant Feature[a]	Supporting Feature
Comparison		10
Description	6	0
Enumeration		11
Labeling		1
Paraphrase		3
Provide instruction or guidance		3
Scenario	12	0
Sequencing		9

[a]The numbers represent the total number of selections in which a feature occurred as either a dominant or supporting feature.

We identified a total of six supporting features in the mathematics selections: *comparison, enumeration, labeling, paraphrase, providing instruction or guidance,* and *sequencing*, of which *comparison* and *enumeration* were the most frequently identified. The textbooks sometimes assist students by providing instruction or guidance in the form of anecdotal notes and parenthetical references (e.g., noting in parentheses at the end of a word problem that students should use 365 days when performing a calculation involving years).

Table 31 provides a list of the features identified in the word problem tasks that call for language production and the number of selections in which they were identified across topics.

We identified six features in the mathematics tasks that require language production: *comparison, description, explanation, hypothesis, justification,* and *writing a problem or question*. *Explanation* appears most frequently in the problem statement or question of the word problem (e.g., Does she have enough material to build a tree house? Explain.). The features are spread evenly across the selections and textbooks, with the exception of instructions for students to write a problem or question. That feature occurs only in selections from one of the three textbooks used in the analyses.

Table 31

Productive Language Features Identified in Mathematics Tasks Across Topics

Features	Total [a]
Comparison	4
Description	3
Explanation	9
Hypothesis	1
Justification	2
Write problem or question	4

[a]Total indicates the number of selections in which the features occurred.

Science. Not unexpectedly, the rhetorical mode identified in all 12 science selections is *exposition*. Indeed, the primary goal of the science texts is to provide information about scientific phenomena by explaining the "how" and the "why" of those phenomena. Table 32 provides a list of all the dominant and supporting text features identified in the science selections and the number of selections in which each feature occurred.

Four dominant text features were identified for science: *classification*, *description*, *explanation*, and *sequencing*. *Description* is present in all 12 passages, while *explanation* occurs in five. *Classification* and *sequencing* may be topic specific, since they only occur in two selections each.

We identified a total of 17 supporting text features. Of the 17, *enumeration* and *labeling* occur most frequently, appearing in all 12 passages, followed by *comparison*, *definition*, and *references to other text or visual support*, which each occur in 10 of the science selections. The textbooks provide *references to other texts or visuals*, such as reference to an activity, experiment, or a specific page in the textbook, to help make concepts more concrete for students and/or to scaffold material that students have already covered in previous chapters.[18] *Analogy* and *simile*, while typically considered stylistic devices in language arts, seem to fulfill a different purpose in the science selections by providing an authentic context to help explain a concept or to make a comparison (e.g., "*Like a spinning skater who pulls her arms in close to her sides, the spinning tornado gets faster and faster*") (Moyer et al., 2000, p. 164).

[18] May on occasion refer reader to a visual outside the selected text.

Table 32

Organizational Features in Fifth-Grade Science Textbook Selections

Features	Dominant Feature[a]	Supporting Feature
Analogy		2
Classification	2	2
Comparison		10
Description	12	0
Definition		10
Enumeration		12
Exemplification		9
Explanation	5	6
Labeling		12
Paraphrase		7
Provide instruction or guidance		3
Questions		8
Reference to text or visual		10
Scenario		2
Sequencing	2	5
Simile		2
Summary		2

[a]Number of selections in which a feature occurs as either a dominant or supporting feature.

The sample text below is excerpted from the science selection in Appendix A, *Measuring Mass and Volume*, and is provided here to illustrate the dominant feature *description* and the supporting features *definition*, *paraphrase*, *comparison*, and *labeling*.

> The volume of an object is the amount of space it takes up **[definition]**. For example, an inflated balloon takes up more space—has greater volume—than an empty balloon. Volume can also be used to express capacity—that is, how much material something can hold **[definition via paraphrase]**. A swimming pool can hold a lot more water than a teacup can.
>
> The basic unit of volume in the metric system is the cubic meter (m3). But because 1 m3 is such a large amount, the liter (L) is more commonly used. A liter is slightly larger than a quart **[comparison]**. Many soft drinks are sold in 2-L containers. Units used to measure smaller volumes include the centiliter (cL), which is one hundredth of a liter, and the milliliter (mL), which is one thousandth of a liter.
>
> A graduated cylinder, which is often called a graduate **[labeling]**, is used to measure liquid volumes. Using a graduate is similar to using a measuring cup **[comparison]** (Badders et al., 2000, p. C11).

In this excerpt, the notion of *volume* is presented through a series of descriptions that evoke visual images of everyday objects such as a balloon, a swimming pool, and soft drink containers. The supporting features interact as part of the dominant descriptive effort to explicate the concept of volume.

Social Studies. To varying degrees, a type of storytelling or narrative occurred in all 12 selections in which events or descriptions are often related to the reader in the third person (e.g., *he was frustrated by the changes other people made in his original draft of the Declaration of Independence*). However, this narrative voice is employed for the purpose of presenting information about historical people, places, dates, and events instead of for the purpose of storytelling. Thus, while the primary goal of the textbooks is expository in nature, the use of narrative as a means for presenting information is so central to the social studies selections that the two rhetorical modes combine to form a special classification we are referring to here as *exposition through the use of narration*.

A list of the dominant and supporting text features identified in the social studies selections is provided in Table 33.

Table 33

Organizational Features in Fifth-Grade Social Studies Textbook Selections

Features	Dominant Feature[a]	Supporting Feature
Classification		1
Comparison		6
Contradiction		2
Description	12	0
Definition		9
Enumeration		12
Exemplification		10
Explanation	4	7
Labeling		12
Paraphrase		8
Questions		5
Quotation		11
Reference to text or visual		7
Sequencing	3	7

[a]Number of selections in which a feature occurs as a dominant or supporting feature.

We identified three dominant text features in the selections analyzed: *description, explanation*, and *sequencing*. *Description* is present in all 12 text selections, while *explanation* plays a dominant role in four selections and *sequencing* only occurs in three. *Explanation* may be topic specific, since it only occurs in selections about the *Declaration of Independence* and the *Industrial Revolution*, as does *sequencing*, which occurs in two selections about the *Declaration of Independence* and one about *Pilgrims*. This may not be surprising since learning about the Declaration of Independence and the Industrial Revolution requires analysis of the wording and purposes of the Declaration of Independence and understanding how and why different inventions changed the way people worked during the Industrial Revolution. It is also natural that sequencing would play a role in the topics *Declaration of Independence* and *Pilgrims* since both require an understanding of the sequence of events that led to or resulted in other events. *Slavery* on the other hand requires more description because the fifth-grade curriculum focuses on early American history, which involves learning about how African Americans lived and functioned in early American society, not the events leading to the Civil War.

Fourteen supporting features were identified. *Enumeration* and *labeling* occur most frequently (in all 12 selections). *Quotation* also appears frequently, occurring in 11 selections, as does *exemplification*, which appears in 10. Quotations are drawn from primary sources and have multiple purposes including: to exemplify an idea, to add emphasis, or to add descriptive detail (e.g., " *'Saturday nights we'd slip out of the quarters and go to the woods,' Jones recalled.*" [Armento et al., 1999, p. 407]).

The sample text below is excerpted from the social studies selection in Appendix A, *The Industrial Revolution*. It illustrates the dominant feature *description* and the supporting features of *labeling*, *comparison*, *cause and effect*, *explanation*, and *definition*.

> At the time of Britain's Industrial Revolution, the young United States was still mainly a land of farms. Before long, though, a British mechanic named Samuel Slater **[labeling]** would bring the Industrial Revolution to the United States. His yarn-spinning machine would come to represent the beginning of a new way of life for our country.
>
> Because of the Industrial Revolution, no other country in the world could make cloth as cheaply as Great Britain **[comparison]**. The British wanted to keep their profitable technology a secret. So they passed laws making it illegal to export machines or machine plans **[cause and effect]**. The people who operated machines in cotton factories were not even allowed to leave the country.

> In 1789 Samuel Slater memorized the plans of the British spinning machines. He had heard that, because of the free market in the United States, business owners there would pay for this new technology **[explanation]**. In a free market, producers of goods and services freely decide how to use resources in response to demand **[definition]**. People in the United States wanted to start their own business in making cloth (Banks et al., 2001, pp. 404-405).

In this excerpt, the text *describes* the beginning of the industrial revolution in the United States through the efforts of Samuel Slater. The dominant feature is realized through the interaction of the supporting features such as *comparison* (e.g., contrasting Britain's technological expertise with the world's) and *definition* (e.g., defining what a free market is).

Frequency of Occurrence of Supporting Features. An important part of characterizing the organizational features of texts for each subject area includes determining the level of frequency with which features occur. This informs test development by indicating which features are most critical to students when reading subject-matter textbooks. The frequency of rhetorical modes and dominant features was noted in the analyses above as either present or not present in a selection. In this part of the analysis, we determined the frequency of supporting features not only by identifying their presence, but also by noting if they occur in a selection just once or multiple times. Table 34 provides the frequency of occurrence of supporting features within and across subjects.

In the mathematics tasks that require language output, only two of the six task features identified occur multiple times (*description* and *explanation*). The other four features all occur just once per selection (see Table 35 for the frequency of features in mathematics tasks that require language output). Since each mathematics selection is a compilation of word problems, the results indicate that tasks requiring language production occur infrequently overall (i.e., they occur in 24 out of the 212 word problems analyzed, 11% of the total).

Table 34

Frequency of Occurrence of Supporting Features Across Subjects

Features	Mathematics			Science			Social Studies		
	Single Occurrence	Multiple Occurrences	Math Total[a]	Single Occurrence	Multiple Occurrences	Science Total	Single Occurrence	Multiple Occurrences	Social Studies Total
Analogy				2		2			
Classification				1	1	2		1	1
Comparison	1	9	10	5	5	10	1	5	6
Contradiction							2		2
Definition				1	9	10	5	4	9
Enumeration		11	11	4	8	12	2	10	12
Exemplification				2	7	9	7	3	10
Explanation					6	6		7	7
Labeling		1	1	3	9	12		12	12
Paraphrase	3		3	2	5	7	2	6	8
Provide instruction or guidance	1	2	3	3		3			
Questions				5	3	8	4	1	5
Quotation							4	7	11
Reference to text or visual				2	8	10	4	3	7
Scenario				2		2			
Sequencing		9	9	2	3	5	1	6	7
Simile				2		2			
Summary				2		2			

[a]Total number of selections in which features occur (12 selections maximum for each subject).

Table 35

Frequency of Productive Language Features in Mathematics Tasks

Features	Single Occurrence	Multiple Occurrence	Total
Comparison	4		4
Description	2	1	3
Explanation	5	4	9
Hypothesis	1		1
Justification	2		2
Write problem or question	4		4

Contexts in Which Supporting Features Occur. As mentioned above, we also examined the types of textual contexts in which the supporting features occur. Four contexts were identified in the selections analyzed: sentence (occurring in a single sentence), multi-sentence (occurring in two or more adjacent sentences), paragraph (predominant in an entire paragraph), and multi-paragraph (occurring in two or more adjacent paragraphs). Table 36 provides data on the contexts in which each supporting feature was identified across subjects.

A list of all supporting text features identified is provided in the far left column with the contexts given under each subject area header. The numbers represent the number of text selections in which a feature was identified in a given context. Thus the numbers are not absolute numbers; that is, they do not represent the total number of times a *comparison*, for example, was made across all sentences. Rather, in mathematics, *comparison* was identified at the sentence level in ten selections and at the multi-sentence level in four. Although these counts are aggregated at the level of the selection and do not represent discrete occurrences of a feature, they do provide a sense of the types of contexts in which different features occur and the relative dispersion across the selections within a subject area. This information will be applied in our test development efforts, as frequently occurring features should be assessed in the types of linguistic environments in which they typically occur.

Table 36

Contexts in Which Supporting Features Occur Across Subjects

	Mathematics		Science				Social Studies			
Features	Sentence[a]	Multi-Sentence	Sentence	Multi-Sentence	Paragraph	Multi-Paragraph	Sentence	Multi-Sentence	Paragraph	Multi-Paragraph
Analogy			1		1					
Classification				1		1		1	1	
Comparison	10	4	7	1	4		6	1	3	
Contradiction							2			
Definition			10				9			
Enumeration	11	7	11	2	2		12	3		
Exemplification			8	3	4	1	9	2		
Explanation			6		5		6	4	3	
Labeling	1		11	4	1		12			
Paraphrase	3		7				8			
Provide instruction/ or guidance	3		3							
Questions			8				5			
Quotation							11	1	1	
Reference to text/ or visual			10				7			
Scenario				1	1					
Sequencing	5	8	1	2	3	1		2	3	6
Simile			1		1					
Summary					2					

[a]Total number of selections in which a feature was identified in the particular context for a maximum of 12 in any cell.

The data in Table 36 show that overall supporting features occur most frequently at the sentence level across subjects, although in science, supporting features occur frequently at the paragraph level as well. *Enumeration*, *labeling*, and *definition*, in that order, are the most frequently occurring features at the sentence level. However, *comparison*, *exemplification*, *explanation*, and *sequencing* occur in a greater variety of contexts, depending on the subject area. These findings indicate that supporting features are usually embedded within the dominant features, a finding parallel to that in Butler et al. (2004). We will return to this point in the summary and in Chapter 6.

Chapter Summary

Contrasts occur across the three subjects at each level of analysis. The difference in the writer's purpose from one subject area to another is clearly evident; thus the rhetorical modes vary. The mathematics selections differ from the science and social studies selections in that the primary purpose of word problems is to provide a context for problem-solving practice. The science selections analyzed differ from the social studies selections in that they follow a more traditional expository form in which information is presented, explained, and then sometimes summarized in a fairly straightforward format. The social studies selections, on the other hand, use a narrative form to present information. That is, historical information often reads like a story, unfolding chronologically with details provided through the eyes of historical figures.

A comparison of the number of different types of features occurring across subjects is shown in Table 37.

Table 37

Number of Dominant and Supporting Features Identified per Subject Area

Subject	Dominant Feature	Supporting Feature
Mathematics	2	6
Science	4	17
Social Studies	3	14

Overall, the range of features, especially supporting features, identified in the science and social studies text selections is broader than in mathematics. This difference reflects the longer and more varied nature of the science and social studies texts, which tend to be more dense than a typical word problem due to inclusion of new concepts and explanation or description of processes and events.

Table 38 provides the comparative data for the specific dominant and supporting features across the three subject areas. There are similarities in the specific dominant features identified across the three subject areas. *Description* occurs in 30 of the 36 text selections across subjects. *Explanation* and *sequencing* occur in both science and social studies selections. However, as dominant features, *scenario* only occurs in mathematics and *classification* only occurs in science.

Several supporting text features occur frequently across the three subjects, specifically *enumeration*, *comparison*, and *sequencing*; whereas *labeling*, *definition*, *exemplification*, *paraphrase*, and *references to supporting text or visuals* occur almost exclusively in science and social studies selections.

Paraphrase appears in all three subjects, with different characteristics in each. In our coding of mathematics, we used paraphrase to denote the restatement of numbers in decimal form (e.g., *Each piece of fruit is 3/100, or 0.03, sugar*). Similarly, in science, we used paraphrase to denote restatement of different units of measurement (e.g., *The wind speeds can reach up to 300 km/hr [about 186 mi/hr]*). In social studies, paraphrase appears in the more traditional form in which a word or phrase is restated or a synonym is used in order to define a new word or to provide clarification to the reader (e.g., *Before leaving, they wrote a compact, or agreement*).

One trend that emerged primarily in the science and social studies selections is the frequent use of "instructional devices" to help students access the subject matter in the selections. These devices may be a unique feature of academic prose, used possibly because of the more complex nature of academic discourse compared to oral language and also possibly due to the conceptual difficulty of the content. The instructional devices identified in the present research have some parallels to observations made of the oral language used by teachers in classroom settings (Bailey et al., 2002). For example, in science and social studies there are references to other parts of the textbook, visuals in almost every selection analyzed, and sometimes references to prior experiments and activities, all used as a means of scaffolding material or reminding students of resources available to them. Questions are used in the science and social studies selections to stimulate critical thinking or to preview new information. In mathematics and science, we identified a type of instructional device in which the author provides instruction or guidance to help students solve a problem or understand new information, for example, by providing students equivalent forms of measurement that may be used to solve a problem.

Table 38

Organizational Features in Fifth-Grade Textbook Selections Across Subjects

Features	Mathematics		Science		Social Studies	
	Dominant Feature[a]	Supporting Feature	Dominant Feature	Supporting Feature	Dominant Feature	Supporting Feature
Analogy				2		
Classification			2	2		1
Comparison		10		10		6
Contradiction						2
Description	6		12		12	
Definition				10		9
Enumeration		11		12		12
Exemplification				9		10
Explanation			5	6	4	7
Labeling		1		12		12
Paraphrase		3		7		8
Provide instruction or guidance		3		3		
Questions				8		5
Quotation						11
Reference to text or visual				10		7
Scenario	12			2		
Sequencing		9	2	5	3	7
Simile				2		
Summary				2		

[a]Number of selections in which a feature occurs as a dominant or supporting feature (12 selections maximum for each subject).

As pointed out earlier, we identified the use of what are typically considered writing devices (*analogy* and *simile*) in science, which are used like the "instructional device" feature discussed above. In science, they are intended to help the reader, not to add stylistic flair. In addition, *scenario* is occasionally found in science selections. Much like the scenarios used in mathematics, short descriptions of real-life situations are embedded in science selections to exemplify a concept or idea and make it more vivid to the reader. The following made-up example is typical of the types of scenarios in science textbooks: *If you moved to a new neighborhood, how would you make new friends? You might go introduce yourself to your new neighbors and invite them over for a barbecue or for tea*. This example also includes a question, which is typical of many science selections.

Finally, it should be noted again that supporting features are typically embedded in dominant features, such as *description* or *explanation*, in the service of expanding or adding detail to a text. Sometimes supporting features also occur in paragraph or multi-paragraph contexts, providing textbook authors a means of exemplifying concepts on a broader scale, labeling or defining new terms in greater detail, or paraphrasing information to ensure that ideas are clear to students.

Taken together, the results of these analyses and the analyses presented in earlier chapters are critical to the creation of test specifications. The data provide a picture of how language is used to accomplish different goals in student textbooks and how textbooks attempt to provide support for students as they are reading, as teachers do orally while conducting lesson. We turn now to a synthesis of all the data into subject area text profiles.

CHAPTER 6:

SYNTHESIZING AND UTILIZING EMPIRICAL DATA FOR TEST DEVELOPMENT PURPOSES

In Chapters 2-5 we provided empirical data that help answer the two research questions presented in Chapter 1. In this chapter we synthesize the results from those chapters to answer the second research question more explicitly. The second research question asks: *How do texts in different subject areas compare to one another in terms of identified characteristics?* Answering this question will be important because commonalities identified are candidates for general academic language proficiency assessment tasks and items, whereas differences are candidates for developing subject-specific language tasks and items.

First, we provide descriptions of the linguistic characteristics of each subject area based on the current research. Next, we compare the linguistic features of each subject area, noting the commonalities and differences across subjects. Then we synthesize the results of the current research with those from prior CRESST research and other studies and apply the findings to the test development process in order to show how data synthesized in this chapter can be used to develop language assessment instruments. We turn now to a description of the linguistic characteristics of each subject area.

Table 39 provides a cross-subject-area profile that lists the main linguistic features investigated in this study down the left hand side and the values and ranges for each feature that typify the subject area text selections on the right hand side. Each section of the table contains data drawn from the different analyses performed in the current study (e.g., descriptive features, grammatical features, and so on).

Table 39

Linguistic Profiles of Fifth-Grade Mathematics, Science, and Social Studies Text Selections[a]

	Math	Science	Social Studies
Mean no. of sentences per word problem or paragraph (range)	3 (2-7)	4 (1-8)	4 (1-9)
Mean no. of words per sentence (range)	11 (1-39)	13 (1-37)	14 (3-43)
Lexical diversity ratio	.43	.41	.49
Percentage of all categories of academic vocabulary words[b]	10% (14%)	21% (27%)	24% (24%)
General academic words only	3% (5%)	6% (11%)	3% (7%)
Specialized academic words only	4% (7%)	14% (14%)	9% (11%)
Measurement words only	3% (2%)	1% (1%)	<1%
Proper nouns only (specialized)	<1%	<1%	7% (5%)
Colloquialisms only	<1%	<1%	<1%
Vocabulary features			
Low-frequency words	8% (12%)	8% (12%)	8% (12%)
3-or-more-syllable words	6% (9%)	10% (15%)	12% (16%)
Derived words	2% (4%)	6% (11%)	8% (12%)
No. of unique clause connectors in each subject area	11	7	21
Avg. percentage of nominalizations per selection	<1%	2% (3%)	2% (3%)
Avg. percentage of each sentence type per selection			
Simple sentences	81%	61%	63%
Complex sentences	17%	36%	33%
Other sentence types	2%	3%	4%
Avg. percentage of dependent clauses per selection	6%	29%	28%
Mean no. of passive voice verb forms per sentence	.04	.24	.16
Mean no. of prepositional phrases per sentence	1	1	1
Mean no. of words per prepositional phrase (range)	4 (2-14)	4 (2-17)	4 (2-20)
Mean no. of noun phrases per sentence	.03	.16	.17
Mean no. of words per noun phrase (range)	2 (1-16)	3 (1-23)	3 (1-19)
Mean no. of participial modifiers per sentence	.03	.17	.17

(*table continues*)

Table 39 (*continued*)

Linguistic Profiles of Fifth-Grade Mathematics, Science, and Social Studies Text Selections[a]

	Math	Science	Social Studies
Dominant organizational features			
Classification	0%	17%	0%
Description	50%	100%	100%
Explanation	0%	42%	33%
Scenario	100%	0%	0%
Sequencing	0%	17%	25%
Supporting organizational features[c]			
Comparison	67%	83%	50%
Definition	0%	83%	75%
Enumeration	92%	100%	100%
Exemplification	0%	75%	83%
Labeling	0%	100%	100%
Paraphrase	17%	58%	67%
Provide instruction or guidance	25%	25%	0%
Quotation	0%	0%	92%
Reference to text or visual	0%	83%	58%
Sequencing	75%	42%	58%

[a]Numbers in this table have been rounded to the nearest whole number for percentages and the nearest one hundredth for decimals. [b]Percentages shown are token (type).[c]The five most frequently occurring supporting features in each subject area are listed here, although there is some overlap, resulting in a total number of 10 supporting features in the list. The percentages represent the percentage of selections in which a particular feature was identified.

Linguistic Characteristics of Mathematics Textbook Selections

The descriptive, lexical, grammatical, and discourse features of the mathematics textbook selections are discussed in turn below. A summary then follows that characterizes the general nature of the mathematics selections.

Descriptive Features

In mathematics selections, the mean number of sentences per word problem is 3, with a range of 2-7 sentences per word problem. Mean sentence length is 11, with a range of 1-39 words per sentence.

Lexical Features

The average lexical diversity ratio for mathematics text selections is .43. That is, slightly over half of the words in mathematics appear more than once in a selection (i.e., in a set of word problems). In our analyses of academic vocabulary in mathematics, we found that on average 10% of all word tokens and 14% of all word types in the 12 text selections were identified as academic vocabulary. Typically, there are slightly more specialized academic and measurement words than general academic words. On average, specialized academic words account for 4% of total word tokens and 7% of total word types, whereas measurement and general academic words account for about 3% each of word tokens and 2% to 5% respectively of total word types on average. Few colloquialisms or proper nouns were identified in mathematics selections.[19]

Low-frequency vocabulary accounts for 8% of total word tokens and 12% of total word types on average per selection; 3-or-more-syllable words account for 6% of total word tokens and 9% of word types on average; and derived words account for 2% of total word tokens and 4% of total word types. A total of 11 different clause connectors were identified in the text selections. With a total frequency of 80 occurrences across all the selections (212 mathematics word problems in total), there is approximately one connector in every three word problems. Of these clause connectors, there are 7 types identified as the more challenging adverbial dependent clause connectors, with an average of 9 adverbial clause connectors per 100 sentences and 8 per 1000 words. The most frequent adverbial connector is *if*; other frequently used connectors include *and*, *but*, and *when*. Nominalizations account for less than 1% of total word types and tokens on average.

Grammatical Features

In mathematics selections, the majority of sentences are simple sentences (81%), followed by complex sentences (17%). Percentages of compound and compound/complex sentences are small. Approximately 27% of all clauses identified in mathematics selections are dependent clauses.

[19] Names of people are frequently used in mathematics, but they are not classified as academic vocabulary because they are inconsequential to the content being taught. In social studies, however, students learn the names of people, places, and things, which are considered academic vocabulary because they are consequential to the lessons.

There are few passive voice verb forms (4 per 100 sentences, an equivalent to approximately one passive verb form for every eight word problems) and no passive constructions using "by" in the mathematics selections analyzed. Each mathematics sentence contains an average of 1 prepositional phrase, with a mean of 4 words per prepositional phrase and a range of 2-14 words in length. There are slightly more noun phrases on average per sentence (3), but the length of noun phrases is shorter than prepositional phrases (approximately 2 words each). Noun phrases range in length from 1-16 words. Mathematics selections contain few participial modifiers of any kind at the fifth-grade level, with approximately one in every eleven word problems.

Discourse Features

Across subjects, we analyzed the organizational features of discourse in each subject area, including rhetorical mode, dominant organizational text features, and supporting text features. As explained in Chapter 5, since rhetorical mode is a feature of extended discourse and not mathematics word problems, we did not perform this analysis on the mathematics selections.

Description and *scenario* were identified as the dominant organizational features in mathematics selections. All 12 selections contain word problems with *scenarios*, which consist of descriptions of real-life situations followed by a task; 6 selections also contain *descriptions,* in which the word problem set up contains a description of a numerical problem but no real-life scenario.

A total of 6 supporting organizational features were identified in mathematics selections, among which *enumeration* and *sequencing* occur most frequently. Additionally, we analyzed mathematics tasks that require language production. Six task features were identified, among which *comparison* and *explanation* are the most frequent.

Summary

Overall, mathematics word problems at the fifth-grade level contain little academic vocabulary, are mostly composed of simple sentences, and do not appear to be grammatically complex according to the analyses presented above. The dominant organizational features of word problems are *description* and *scenario*, with several frequently occurring supporting features used to provide the detail necessary for students to set up the mathematical computations needed to solve the word problem, such as *enumeration* and *sequencing*. The word problem below is an example of word problems typical of those analyzed here (see Appendix A for other sample word problems).

> A large can of juice contains 1.5 liters and sells for $2.09. A smaller can of the same juice contains 750 milliliters and sells for $0.98. Which is the better buy? (Remember: There are 1000 milliliters in 1 liter) (Willoughby et al., 2003, p. 268).

This word problem is typical in that it is of average length (i.e., 3 sentences), and the dominant organizational feature is *scenario* (e.g., it describes a context for problem solving in which students are required to compare the price and size of two different cans of juice). It has 3 supporting organizational features: *comparison* (e.g., the comparative adjectives *smaller* and *better*), *enumeration* (the size and price of two juice cans is enumerated across two sentences), and *providing instruction and/or guidance* (e.g., measurement equivalents are provided). The sample includes measurement words (e.g., *liters*) and also a mathematics-related colloquialism (e.g., *better buy*).

Linguistic Characteristics of Science Textbook Selections

The descriptive, lexical, grammatical, and discourse features of the science textbook selections are discussed in turn below. A summary then follows that characterizes the general nature of the science selections.

Descriptive Features

In science, the mean number of sentences per paragraph is 4, with a range of 1-8 sentences per paragraph. Mean sentence length is 13 words, with a range of 1-37 words per sentence.

Lexical Features

The average lexical diversity ratio for science text selections is .41, indicating that as with mathematics, slightly over half the words in science are repeated in a typical selection.

Academic vocabulary analyses revealed that on average approximately 21% of all word tokens and 27% of word types in science selections are considered academic vocabulary. There are typically more specialized academic words in science selections than other categories of academic vocabulary. Specialized words account for about 14% of total word types and tokens. General academic vocabulary makes up about 11% of total word types and 6% of total word tokens on average. Measurement words, colloquialisms, and proper nouns were also identified in science selections, but they each account for less than 1% of total words on average.

Low-frequency vocabulary and 3-or-more-syllable words account for approximately 8% and 10% of all word tokens respectively and 12% and 15% of all word types on average. Derived words make up about 6% of all word tokens and 11% of all word types. Eighteen different clause connectors were identified in the science selections. With a total of 107 occurrences across selections, there are an average of 9 connectors per selection. Of the 17 different types of connectors identified, 15 are adverbial dependent clause connectors, with an average of 18 adverbial clause connectors per 100 sentences and 14 per 1000 words. The most frequent connectors are *when* and *as*; other frequent connectors include *because*, *if*, and *and*. Nominalizations account for 2% of total word tokens and 3% of total word types on average.

Grammatical Features

In science selections the majority of sentences are simple sentences (61%), followed by complex sentences (36%). Percentages of compound and compound/complex sentences are small (about 3% combined). Approximately 29% of all the clauses identified in science selections are dependent clauses.

There are on average .24 passive voice verb forms per sentence (an equivalent of one passive verb form every fourth sentence in a typical science selection) and .03 passive constructions with "by" per sentence. Prepositional phrases appear frequently, with approximately 1 prepositional phrase per sentence, a range in length of 2-17 words, and a mean of 4 words. There are slightly more noun phrases per sentence (3). The range in length of noun phrases is longer as well (1-23 words), with a mean of 3 words per phrase. Typically, there are .17 participial modifiers per sentence, or one every fifth sentence in science text selections.

Discourse Features

The rhetorical mode used in all 12 science selections is *exposition*. We identified four dominant organizational features: *classification, description, explanation,* and *sequencing*. Among the four features, *description* is found in all the selections, whereas *explanation* occurs in five. *Classification* and *sequencing,* on the other hand, may be topic specific since they only occur in selections for two of the topics.

A total of 17 supporting features were identified, of which *enumeration* and *labeling* occur most frequently and can be found in all 12 selections. Other frequently used features include *comparison, definition,* and *references to other text or visual support*, which occur in 10 science selections each.

Summary

Overall, science selections at the fifth-grade level contain a variety of general and specialized academic vocabulary and are mostly composed of simple sentences. The sentence structures do not appear to be grammatically complex, although the sentences tend to be longer and more varied than in mathematics (e.g., they contain more passives and participial modifiers). Science selections also contain a broader range of dominant and supporting features than mathematics. The paragraphs below are excerpted from the sample science selection in Appendix A, which exhibits some of the features that typify the types of science texts analyzed in this research.

> The heaviness of each package is directly related to its mass. Mass is a measure of how much matter something contains. Weight is a measure of the force of gravity acting on a mass. So the more matter an object contains—the greater its mass—the more it will weigh.
>
> A spring scale, which is used to weigh objects, measures the effect of gravity on an object. To find an object's mass, you have to use a balance, like the one shown on page C11.
>
> The most common metric units used to measure are grams (g) and kilograms (kg). A penny has a mass of about 2 g. A kilogram is one thousand times the mass of a gram. A large cantaloupe has a mass of about 1 kg (Badders et al., 2000, pp. C10-C11).

This selection is from the topic *Matter* and is representative of the science selections in the study in terms of the descriptive data and the analyses of vocabulary, grammar, and basic organizational features. Because it teaches students about measuring mass and volume, it contains a higher than average number of measurement words (e.g., kilogram), and also has more 3-or-more-syllable and morphologically-derived words than the average science selection. The first paragraph provides examples of nominalization (e.g., *the heaviness of each…*), specialized academic vocabulary (e.g., *the force of gravity*), and measurement words (e.g., *grams [g]*).

In the paragraphs shown (and in the entire selection), the rhetorical mode is *exposition* and the dominant feature is *description*. Supporting features include *comparison* (e.g., *…the more matter an object contains—the greater its mass…*), *definition* (e.g., *mass is a measure of how much matter something contains.*), and *reference to other text or visual support* (e.g., *…like the one shown on page C11*). In subsequent paragraphs, this selection contains the supporting feature *sequencing* (e.g., it provides the steps for measuring volume).

Linguistic Characteristics of Social Studies Textbook Selections

The descriptive, lexical, grammatical, and discourse features of the social studies textbook selections are discussed in turn below. A summary then follows that characterizes the general nature of the social studies selections.

Descriptive Features

The mean number of sentences per paragraph in social studies selections is 3.98, with a range of 1-9 sentences per paragraph. Mean sentence length is 13.52 words, with a range of 3-43 words per sentence.

Lexical Features

The average lexical diversity ratio for social studies text selections is .49, which is higher than for mathematics or science. On average approximately 24% of all word tokens and types in social studies selections were identified as academic vocabulary. There are typically more specialized academic words than any other category of academic vocabulary. Specialized vocabulary accounts for about 9% of total word tokens and 11% of total word types on average. Proper nouns make up a fairly high percentage of academic vocabulary (about 7% of total tokens and 5% of total types on average), but the use of measurement words and colloquialisms is rare, accounting for less than 1% of total words each in a selection. General academic words make up approximately 3% of total word tokens and 7% of total word types on average.

Low-frequency vocabulary and derived words each account for about 8% of total word tokens and 12% of total word types on average. Words with 3-or-more-syllables occur more frequently, accounting for about 12% of total word tokens and 16% of total word types on average. A total of 21 different types of clause connectors were identified, with 105 occurrences across all the selections and an average of 9 connectors per selection. Seventeen of the 21 connectors are adverbial dependent clause connectors, with an average of 10 connectors per 100 sentences and 7 per 1000 words. The most frequently occurring connectors are *when*, *and*, and *as*. Other frequent connectors include *but* and *after*. Nominalizations account for 2% of total word tokens and 3% of total word types on average.

Grammatical Features

The majority of sentences in social studies are simple sentences (63%), followed by complex sentences (33%). The number of compound and compound/complex sentences is small (less than 5% combined). Approximately 30% of all clauses identified in social studies selections are dependent clauses.

The average number of passive voice verb forms per sentence is .16 (about one passive verb form every fifth sentence in social studies), and the average number of passive constructions with "by" is .02. Each sentence in social studies contains approximately 1 prepositional phrase, with a mean length of 4 words each and a range of 2-20 words in length. There are more noun phrases per sentence (3) on average than prepositional phrases, but the mean length is shorter than prepositional phrases (3 words). The noun phrases range in length from 1-19 words. There are approximately .17 participial modifiers per sentence, or about one every fifth sentence in social studies selections, as in science.

Discourse Features

In all 12 social studies selections, we identified a specialized rhetorical mode that combines exposition with a story-telling or narrative form of presenting information, which we call *exposition through the use of narration*. Three dominant text features were identified: *description, explanation*, and *sequencing*. Of the three, *description* is present in all 12 selections, *explanation* occurs in four, and *sequencing* is found in three. Both *explanation* and *sequencing* may be topic specific, since they only appear in selections from two of the four topics.

A total of 14 supporting features were identified, among which *enumeration* and *labeling* can be found in all 12 selections. Another two features that occur frequently are *quotation* and *exemplification*.

Summary

According to our research, fifth grade social studies selections contain a variety of academic vocabulary and low-frequency, 3-syllable, and derived words. Except for proper nouns, though, social studies vocabulary features share many similarities to science. The selections are composed of mostly simple sentences and approximately 30% complex sentences. Grammar does not appear to be complex in social studies, although it tends to contain longer sentences, prepositional phrases, and noun phrases than the other two subject areas. In terms of organizational features, social studies is similar to science, with the exception of a few unique features, such as the use of *quotation*. The example paragraphs below, excerpted from the sample social studies selection in Appendix A, exemplify some of the features considered to be typical in social studies.

> Slater slipped out of the country and came to the United States. Soon he was hired by a merchant to build spinning machines in Rhode Island. By 1790 Slater had built the first American machines to spin cotton into yarn.
>
> Slater had to pay a high price for the cotton he used in his factory, which limited his profits. In 1793, however, an American inventor built a machine that made cotton cheaper to produce. His name was Eli Whitney.
>
> Whitney heard planters talk about how long it took enslaved workers to remove the stubborn seeds stuck to cotton. Whitney invented the cotton gin in ten days. Whitney's gin, which is short for "engine," helped workers clean up to 50 times more cotton than they could by hand.
>
> As you can see from the bar graph below, cotton production boomed after the invention of the cotton gin. Together, slave labor and the cotton gin made growing cotton more profitable. Many planters became more determined to keep slavery alive (Banks et al., 2001, pp. 405).

The selection this excerpt came from is the second shortest of all the social studies texts, however the features of this text, such as average sentence length and number of sentences per paragraph, are in line with the subject area averages, which is the hallmark of what makes a text "typical." This particular text selection does, however, contain more passive phrases with "by" than other texts (e.g., *…in houses built by the mill owners*) and more specialized academic vocabulary (e.g., *merchant, profitable*), in part due to the topic *Industrial Revolution*, which contains many new and specialized terms for inventions. There is an example of nominalization in the fourth paragraph above (e.g., *cotton production*), a prenominal past participial modifier (e.g., *enslaved workers*), and a coordinate clause (e.g., *…and the cotton gin…*).

The rhetorical mode is *exposition via narration*, as the selection narrates historical events in the context of the lives of individuals (e.g., *Whitney heard planters talk…*). The dominant organizational feature of this selection is *description* since many of the inventions are described in terms of what they do. Supporting features include *explanation* (e.g., explains why new inventions help people do things better or more efficiently), *comparison* (e.g., compares how much faster work could be done with new inventions), *labeling* (e.g., *his name was Eli Whitney*), and *sequencing* (e.g., by naming the years when people invented new machines). Later in the selection (see Appendix A), a mill girl's diary is quoted, providing an example of the supporting feature *quotation*.

Comparison of Linguistic Features Across Subject Areas

In the subsections below, we briefly discuss the major sections of the cross-subject-area profile.

Descriptive Features

Across subjects, we found that the mean number of sentences ranges from 3.13 sentences per mathematics word problem to 4.18 sentences per science paragraph. At the sentence level, mean sentence length is slightly shorter in mathematics (11) than in science (13) and social studies (14). Social studies has a slightly wider range of sentence lengths (3-43 words) than in mathematics (1-39) and science (1-37).

Lexical Features

Based on examination of type/token ratios, we found that social studies (.49) is slightly more lexically diverse than either mathematics (.43) or science (.41). However, the diversity ratios across subjects appear to be relatively low given the assumption that one purpose of the textbooks is to introduce new grade-appropriate lexical items to students.

Comparing academic vocabulary usage across subjects, we found that mathematics selections contain fewer academic words than science and social studies overall, whereas science and social studies have comparable percentages of academic vocabulary. In examining the percentages of academic words by subcategories, we observed that all subjects contain more specialized academic vocabulary than any other subcategory. However, the proportions of other subcategories of academic words vary slightly from subject to subject. Mathematics contains a larger percentage of measurement words than science and social studies. On the other hand, science has the largest proportion of general academic vocabulary across subjects. Although social studies does not have as many general academic vocabulary words, it contains the highest percentage of proper nouns.

In terms of low-frequency vocabulary, the percentages of total word types and tokens are similar across subjects. Low-frequency words play a relatively minor role in total word counts (about 8% overall), but a slightly greater role in total word types (about 12%) for all three subjects. Across subjects there are more 3-or-more-syllable words than there are derived words, both in types and tokens. In both cases, however, proportions of both 3-or-more-syllable and derived words in total word counts/word types are similar for science and social studies (15%-16% for 3-or-more-syllable words, 11%-12% for derived words), but the percentages are smaller in mathematics (9% for 3-or-more syllable words, 4% for derived words).

Overall, there are more unique clause connectors (types) in science and social studies than in mathematics, but all three subjects have some frequently occurring connectors in common, such as *and*, *when*, *if*, and *but*. Nominalizations appear infrequently across subjects. In science and social studies selections, they account for about 2% of total word counts and 3% of word types, and in mathematics they account for less than 1% of total words.

Grammatical Features

The majority of sentence types across subjects are simple sentences, followed by complex sentences. Mathematics has the highest percentage of simple sentences (81%), whereas in science and social studies about 60% of the sentences are simple sentences. Across subjects approximately 26%-29% of total clauses are identified as dependent clauses.

Use of passive voice verb forms in general and passive constructions with "by" varies by subject, with less than 1 passive form per sentence on average across subjects. Passive constructions in mathematics are almost nonexistent, whereas passive voice verb forms occur with higher frequency in science (.24 per sentence) than in social studies (.16).

With regard to prepositional phrases, the usage is the same across subjects, with the average number per sentence being 1. The average length of prepositional phrases is approximately 4 words per phrase across subjects. The average number of noun phrases per sentence is 3 for all subjects.

There are few participial modifiers of any kind (e.g., past or present) in the fifth-grade text selections analyzed, although there are slightly more in social studies (approximately 17 per 100 sentences) than in science (16). Mathematics has considerably fewer participial modifiers than the other two subjects (3 per 100 sentences).

Discourse Features

We observed many contrasts across subjects at each level of analysis. First, the rhetorical mode varies across subjects according to the purpose for writing. The primary purpose of mathematics word problems is to provide problem-solving contexts. The word problems are typically limited in length and thus do not provide the extended discourse necessary for establishing rhetorical mode. Therefore, this feature could not be identified in the mathematics selections. Science and social studies both follow an expository form to present information; however, their rhetorical modes differ slightly from each other: science selections use a more traditional, straightforward expository form, whereas social studies selections employ a story-telling narrative form.

Summary

Overall, science and social studies contain similar numbers of dominant and supporting features, whereas mathematics selections exhibit less variety. For dominant text features, we found that *description* occurs across all three subjects and was identified in 30 of the 36 text selections analyzed in the current research. *Explanation* and *sequencing* occur in both science and social studies, but not in mathematics. *Scenarios*, on the other hand, occur only in mathematics.

Several supporting features were identified across subjects, the most frequent of which are: *enumeration, comparison*, and *sequencing*. In contrast, *labeling, definition, exemplification, paraphrase,* and *references to supporting text or visuals* are found almost exclusively in science and social studies. Additionally, social studies differs from science and mathematics in that it has *quotation* as a frequent supporting feature.

Statistical Comparison of Linguistic Features Across Subject Areas

Key features from descriptive, lexical and grammatical text analyses were chosen for statistical analysis based on the degree of contrast they displayed across the three subjects, as shown in Table 6.4 above. The univariate analysis of variance (ANOVA) procedure was conducted to test the significance in mean differences across subjects using, as appropriate, either the mean percentage of a given text feature (i.e., differences in the mean number of sentences per paragraph) or a standardized mean value (i.e., mean ratio of number of unique word types to total number of word tokens).

In every case, because we compare percentages or other standardized values, the contrasts we analyze across subject areas are meaningful despite differences in the overall number of words in each selection. The ANOVAs were conducted with Bonferroni corrections (a conservative adjustment) due to the larger number of multiple comparisons that could have resulted in significant findings by sheer chance. With just 12 text selections for each of the subjects, the ANOVA results should be interpreted with caution. We therefore graphed confidence interval (CI) bands for each of the individual subject area bars in Figures 1 and 2 below.[20] These CIs are set at $p<.05$, that is, there is a 95% chance that the mean values for a given language feature fall within the band around the mean. A number of these bands are quite wide (e.g., percentage of participial modifiers per sentence in social studies) which reflects the large degree of variation across the 12 selections within a subject. The CI bands allow us to interpret the ANOVA results more conservatively: where subject means for a given text feature are found to be significantly different and CI bands are non-overlapping, we can be more confident that any differences detected across subjects truly exist.

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[20] The calculations for these CIs were based on the 12 text selections of each subject area (each subject area conducted independently) in order to be more conservative. We did this rather than rely on the less stringent CIs based on the combined total of 36 selections across subject areas that are automatically produced by the ANOVA procedure.

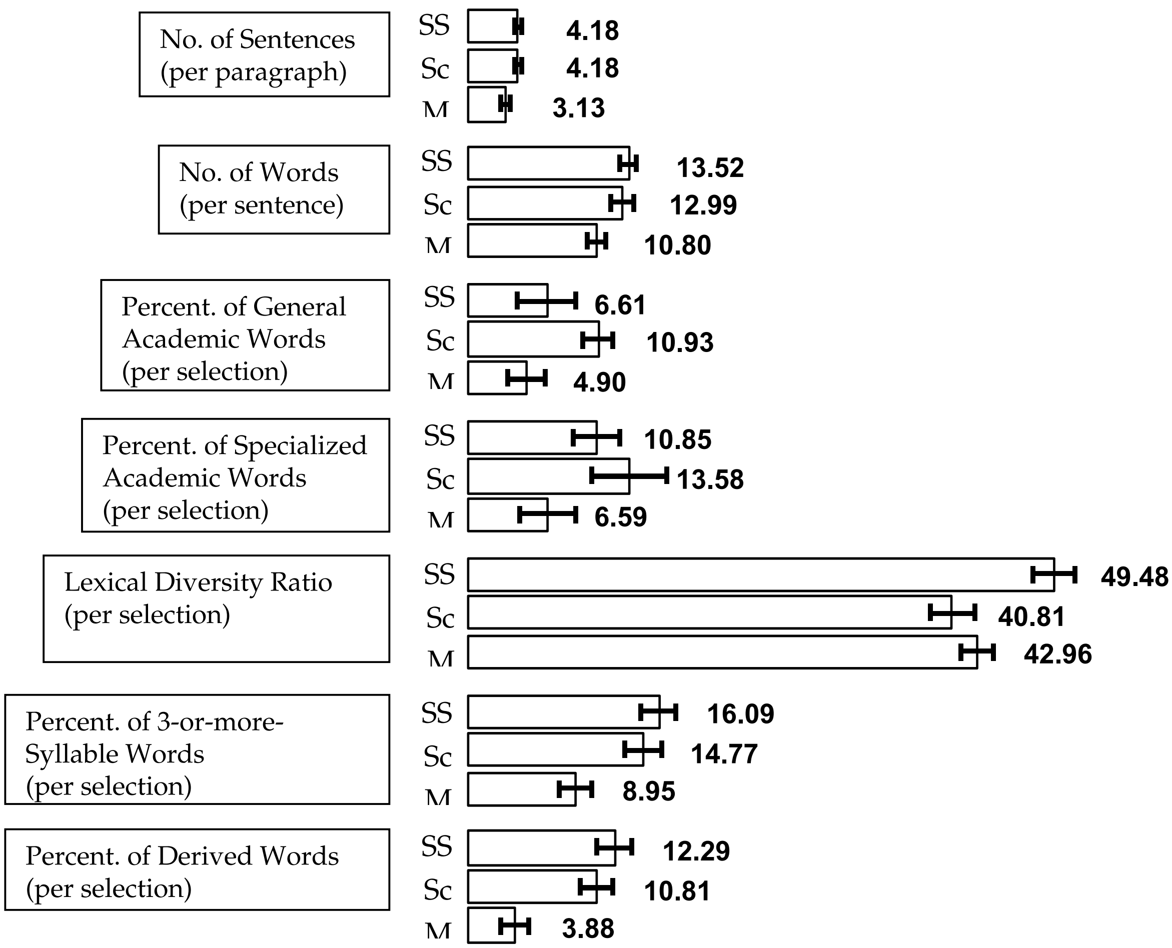

Figure 1. Linguistic Profiles of Fifth-Grade Social Studies (SS), Science (Sc) and Mathematics Text Selections (M): Subject matter averages for descriptive and lexical data.[21]

Figure 1 presents the CI bands for the descriptive and lexical profiles. In five contrasts: *number of sentences and words, specialized academic words, percentage of 3-or-more-syllable and derived words*, mathematics texts have significantly lower means than either science or social studies texts. ANOVA post hoc comparisons were significant at $p<.001$ for all but the contrast between mathematics and social studies for *specialized academic words*, which is significant at $p<.05$ only and has overlapping CI bands that suggest the difference in means in this comparison should be interpreted with caution. Science has significantly more *general academic words* than either mathematics (post hoc comparison $p<.001$) or social studies (post hoc

[21] Data ordered social studies, science, mathematics to reflect overall prevalence.

comparisons *p*<.01), although the latter two do not differ significantly from each other. On just one feature, the *lexical diversity ratio*, social studies texts have a significantly higher ratio of word types to word tokens than either mathematics or science texts (post hoc comparisons *p*<.001). *Lexical diversity ratios* for mathematics and science did not differ significantly.

In terms of findings in the grammatical data (see Figure 2), in one key contrast (*percentage of simple sentences*), mathematics texts have a significantly higher mean than either science or social studies texts (post hoc comparisons *p*<.001). Conversely mathematics has far fewer *complex sentences* per selection on average than either science or social studies (post hoc comparisons *p*<.001). Neither science nor social studies texts differ from one another on these sentence structure features. Mathematics has a considerably lower mean percentage of *passive voice verb forms* and *participial modifiers per sentence* than the other two subject areas (post hoc comparisons between mathematics and social studies for *passive voice verb forms p*<. 01); between mathematics and social studies for *participial modifiers p*<.001; between mathematics and science for both *passive voice verb forms* and *participial modifiers p*<.001). On average social studies texts also have significantly fewer *passive voice verb forms* than science texts (post hoc comparison *p*<.05) but the higher p-value and overlapping CI bands strongly suggest caution when interpreting this finding.

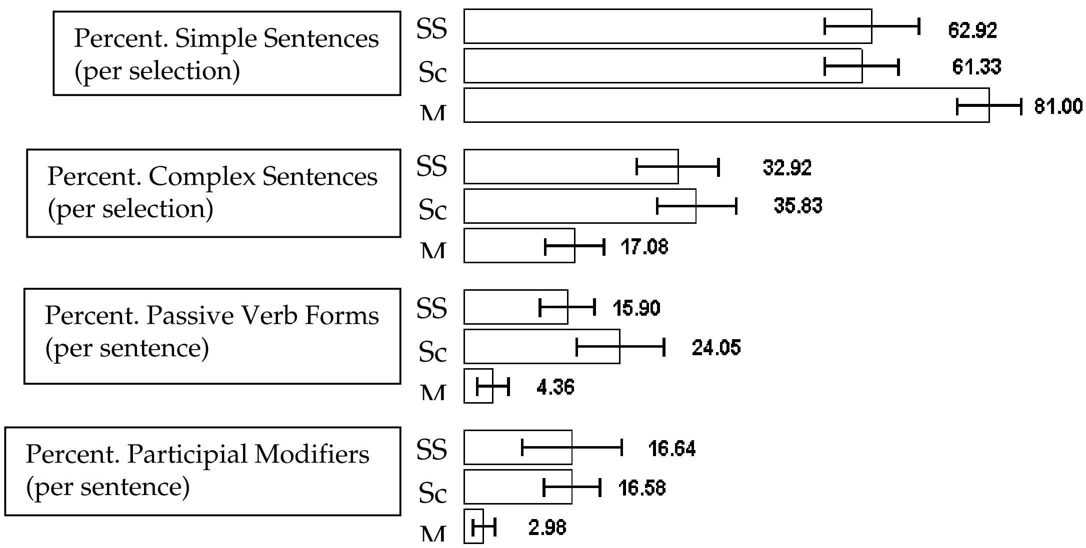

Figure 2. Linguistic Profiles of Fifth-Grade Social Studies (SS), Science (Sc) and Mathematics Text Selections (M): Subject matter averages for grammatical data.[22]

Overall, these analyses show that there are statistically significant differences between the subjects in several areas, although some of the results should be interpreted with caution given the small number (12 selections per subject area) of text selections. However, any results at the sentence and paragraph levels are meaningful as the total number of sentences and paragraphs is more substantial (or in the case of mathematics, where the total number of word problems is 212).

Synthesis with Prior CRESST Research Findings

In Butler et al. (2004), we reviewed and synthesized the CRESST research on academic language in addition to other relevant research studies. We found that many studies could not be compared because the empirical methods used differ from study to study. Furthermore, they used qualitative approaches to analyze and describe academic language such that features of academic language across grade levels and subject areas are not described with enough specificity for the purposes of test development or articulating the trajectory of academic language learning and use across grade levels. In the current research we have emphasized a research

[22] Data ordered social studies, science, mathematics to be consistent with Figure 1.

approach that includes the development of replicable quantitative procedures and strong reliability. Despite these differences in the body of research on academic language, there are areas of overlap in the findings that are helpful in constructing a more detailed picture of the types of language students must manipulate in academic environments.

To this end, we briefly revisit the synthesis in Butler et al. (2004), which includes a discussion of research results from multiple sources.[23] First, we find that a comparison of sentence length across grades and subjects in Butler et al. (2004) is consistent with our findings here, showing an increase in sentence length from mathematics (less than 10 words) to science (approximately 13 words) to social studies (14 words). The use of subordinate clauses was noted in three of the seven studies cited in Butler et al. (2004), which crosses all three subject areas as well as grade levels (see Appendix L) for a review of the Synthesis of Grammatical Features of Language Functions in Textbooks and Printed Materials from the 2004 report). Our findings here indicate that each typical selection in mathematics, science, and social studies is composed of 27%-29% dependent clauses. Future research will further analyze the types of dependent clauses used.

Passive voice, nominal structures, and prepositional phrases were all cited as potential features of academic language in the 2004 synthesis. In the current research, while we found prepositional phrases and noun phrases occur in every sentence across subjects in the fifth-grade texts analyzed, passive voice verb forms only appear in every 4 to 5 sentences for science and social studies. The use of logical connectors was discussed in the context of grammatical features of linguistic functions; many of the same types of connectors were found in the current research, although we have described them in this report as clause connectors. Some of these include *if*, *when*, and *but*. More specificity is possible if the grammar of organizational features described in this report (e.g., comparative adjective forms used for the purpose of comparison, connectors used for the purposes of exemplification or sequencing) were to be analyzed.

Last, in the 2004 report, we discuss the use of language functions in textbooks; in this report, we characterize language functions as a part of a larger category: organizational features of discourse. Of the 8 most frequently identified language

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[23] Note that the synthesis did not include a discussion of academic or descriptive vocabulary features, so these will not be reviewed here.

functions in the 2004 report, 6 appear in the 15 most frequently identified organizational features in this study. They are: *classification, description, comparison, definition, explanation,* and *sequencing* (see p. 51 of Butler et al., 2004). Others appear as well, but less frequently (e.g., *labeling*).

In Bailey et al. (2004), several of the same features identified in the text selections in the current research were identified in the oral discourse of teachers. For example, the use of *exemplification* was noted as a means of supporting learning or presenting new academic vocabulary words during a lesson. *Paraphrase* was used by teachers "…to avoid repair…by first using academic language…they guided and scaffolded students' meaning-making from the outset of the interaction" (p. 32). In the textbook selections, *paraphrase* is sometimes used for the same purpose, i.e., by using a more familiar word after a particularly difficult word; other times it is used in the opposite way (i.e., by introducing a more difficult word in the paraphrase as a means of introducing new academic vocabulary or to define new vocabulary). At the university level Chung and Nation (2003) show that similar techniques are used to help introduce or define new or difficult words in academic texts (e.g., by using parenthetic examples in texts, similar to the *paraphrase* examples we have described in this report).

Bailey et al. (2004) also discuss a category identified in their research as *process/application instruction,* which has a function in oral language similar to two of the features identified in the texts: *providing instruction or guidance* and *questions*. In their research, teachers gave students guidance as to what to pay attention to while doing activities, which is similar to textbook authors referring students to prior chapters to look at diagrams or to remind students of concepts taught in prior lessons. By doing this, textbooks help students focus on relevant or helpful information available to them in the textbook and also help scaffold information. In the same *process/application instruction* category, examples are provided that parallel the current research in which teachers ask leading questions, which direct instruction and build anticipation of the lesson to come. This use of questioning is identical to many of the questions identified in the textbook selections in the current research, which usually are rhetorical in nature and are meant strictly to stimulate critical thought, activate prior knowledge, and/or contextualize new concepts.

Finally, it should be noted that across subjects, most supporting features, such as *enumeration* and *exemplification*, are embedded within dominant features such as *description*, usually for the purpose of expanding or adding detail to the texts, which corresponds to findings in previous research (Butler et al., 2004). This interplay between features is an important feature of all texts and must be taken into consideration not only when teaching students how to read academic texts but also when designing assessments of academic language. We turn now to a discussion of how to apply these empirical data to the test development process.

Implications for Test Development

The goal of the current research is not only to create the descriptions of text features for each subject area provided above, it is also to determine which features should or should not be present in texts selected for assessment purposes and which features of the texts are critical for assessment. Therefore, the profiles can be discussed differentially based upon test developers' needs. Here, we will show which information has applications for selecting texts for test development and which information will play a role in the development of items and tasks.

Text Selection

Texts selected for general language assessment purposes should be representative of the types of texts all students will encounter across subject areas. In the present research, our goal is to develop standards-based language assessment prototype tasks based on authentic materials from each subject area in order to tap student mastery of the range of academic English that is used in the classroom. One part of this range of language used in the classroom is textbooks. A standards-based text selection process will consist of several steps:

1. Selecting texts that reflect subject-area standards.
2. Reviewing the selected texts against an initial set of criteria specific to each subject area.
3. Reviewing the selected texts for cultural and/or other types of bias.
4. Screening the selected texts against specific linguistic criteria for each subject area.
5. Subjecting the selected texts to an expert and teacher review.

A more detailed example of the general procedures that might be followed for Steps 1-3 is provided in Appendix M (General Procedures for Text Selection: Stage 1). After Steps 1-3 have been performed, the text selections would then be typed into an electronic file and a series of analyses corresponding to Step 4 would be run to determine if the linguistic characteristics of the text selections correspond to the text profiles provided earlier in the chapter.

Language features analyzed in the current research that have implications for Step 4 of the text selection process include: (a) the range and number of sentences per paragraph or word problem, (b) the range and number of words per sentence, (c) the lexical diversity ratio, (d) descriptive vocabulary features (percentage of low-frequency, 3-syllable, and derived words), and (e) the balance of different sentence types and clauses present in each selection. These descriptive features help form the basis of judging what is typical or atypical in a text selection.

Item and Task Development

Since textbooks are an integral part of classroom learning, the data generated in this report can be used to determine which linguistic features of textbooks are critical at the fifth-grade level for each subject area and also to help establish trajectories of language complexity across grade levels for each subject area. While the analyses performed in the current research are not exhaustive, they provide evidence of the prevalence of a range of features at the fifth-grade level upon which we can base our item and task development decisions. These features include: (a) nominalizations, (b) frequently-used clause connectors, (c) types and frequency of academic vocabulary, (d) passive constructions, (e) prepositional phrases, (f) noun phrases, (g) participial modifiers, and (h) frequently-used dominant and supporting discourse features. Table 40 provides a sample content framework for developing assessments of academic language proficiency, which lists a selection of the vocabulary, grammar, and text organization features investigated in the current research down the left and the three subject areas across the top.

Table 40

Content Framework for Developing an Assessment of Academic Language Proficiency

	Mathematics	Science	Social Studies
Vocabulary			
Non-academic vocabulary[a]	√	√	√
Academic vocabulary (AV)			
General AV (high-frequency)[b]	√	√	√
Specialized AV (defined in context)	--	√	√
Measurement words	√	√	--
Proper nouns	--	--	√
Clause connectors[c]	√	√	√
Nominalizations	--	√	√
Grammar			
Noun phrases	√	√	√
Participial modifiers	--	√	√
Passive voice verb forms	--	√	√
Prepositional phrases	√	√	√
Organization of Text			
Comparison	√	√	√
Definition	--	√	√
Description	√	√	√
Enumeration	√	√	√
Exemplification	--	√	√
Explanation	--	√	√
Labeling	--	√	√
Paraphrase	√	√	√
Scenario	√	--	--
Sequencing	√	√	√

[a]See Appendix C for a list of the most frequently occurring words across subjects.
[b]See Appendix B for a list of high-frequency general academic words that occur across subjects.
[c]See Appendix D for a list of the most frequently occurring adverbial and coordinate clause connectors.

If we use Table 40 as a guide for determining test content, we might select high-frequency non-academic and general academic vocabulary, prepositional phrases, and *comparison*, *description*, and *sequencing* for inclusion on a general assessment of academic language proficiency. For assessments of subject-specific language proficiency, like the specialized advanced placement and subject area tests high school students often take before going to college, we might instead focus on measurement words for mathematics and science, participial modifiers and passive voice verb forms for science and social studies, and *definition* and *labeling* for science and social studies. Even finer distinctions can be made if all of the features investigated in this research were to be included in such a framework, (e.g., the text organization feature *quotation* is not included in the framework because it only occurs in social studies texts). This is a strong candidate for inclusion in a test of specialized academic language knowledge in social studies.

The information presented in Table 40 has been sequenced in the order it was presented throughout the paper. For actual test development, the features may be re-organized into different categories; for example, grammatical features of text are embedded in the text organization and do not occur discretely. Therefore, students must be able to make meaning out of vocabulary and grammar in order to understand the main and supporting ideas in a text (e.g., students must comprehend comparative adjectives in order to understand that a comparison or contrast is being made; knowledge of adverbial connectors is critical to understanding a sequencing of events).

Chapter Summary

In this chapter, we summarize our findings into draft text profiles for each subject area and a cross-subject-area text profile and then show how the information can be used for test development purposes. These text profiles help to illustrate the differences and similarities between and across mathematics, science, and social studies at the fifth-grade level, in turn helping test developers select appropriate content for general and specialized tests of academic language proficiency. Future research will investigate the use of the features discussed in the current research at other grade levels. This information will feed into a content framework that shows the trajectory of language use for each feature within each content area by grade level. This information is particularly critical as testers work to develop individual items and assessments that distinguish ELs with differing levels of academic language proficiency from one another as well as from grade-to-grade. In addition, it will help test developers determine which combinations of grades form natural clusters. Up to now, testers have selected grade clusters (e.g., grades three through five) with little empirical evidence upon which to base their decisions. Research of this kind not only helps to specify test content but also helps assure that the content of tests is grade-level appropriate.

In the final chapter, we turn to the implications that this research has for test development as well as extensions to other applications in education.

CHAPTER 7:

CONCLUSIONS AND RECOMMENDATIONS

The work described in this report provides new information that will inform the discussion of the nature of academic language. The study also invested considerable effort in the creation of a methodology for conducting comprehensive linguistic analyses of texts. The academic vocabulary and discourse analyses in particular were iterative in that the processes for conducting analyses were developed, piloted, and revised as part of the study. The CRESST Academic English Language Proficiency (AELP) Guidelines for Linguistic Text Analyses (in preparation) used in the analyses for training will be available for future work in this area. This closing chapter highlights the major findings and enumerates their implications for language test development. Additional implications for other areas of educational practice are also briefly discussed. We close with methodological ramifications and the next steps we will undertake in language test development.

Summary of Findings

The text profiles presented in Chapter 6 are important to our understanding of what is unique and what is shared across different subject areas. The three subject-area text selections differed on a number of linguistic features we investigated. However, there were still some important similarities on basic measures of language, such as the average number of sentences used in a word problem or paragraph and the complexity of sentences as measured by the number of dependent clauses. Major differences across all three subject areas included the degree to which they made use of academic vocabulary and passive voice verb forms. Most differences distinguished mathematics from science and social studies; the latter two subject-areas were remarkably similar on most linguistic measures.[24] Specifically, the mathematics texts had shorter sentences, a smaller repertoire of specialized vocabulary, fewer clause connectors, fewer complex sentences, and used fewer *descriptions* and *explanations* than either science or social studies. However,

[24] As mentioned, the word problem format in mathematics may have restricted the findings and does not represent all possible linguistic contexts of mathematics especially instruction. However, we argue that it does represent a fair approximation of the language dmands typical of mathematics assessment contexts.

mathematics had a greater number of simple sentences and made greater use of the *scenario* organizational feature than either science or social studies.

Implications for Language Test Development

The findings have direct application to the selection of texts for use in test development, as well as for content analysis and validation of the linguistic demands of test items (including the stimulus, question and expected response components of test items). Commonalties in linguistic features across subject areas are candidates for assessments of general academic language (domain-general language), whereas differences in linguistic features are candidates for developing subject-area (domain-specific) assessments or subject-specific test modules to add on to a general academic language test.

Implications From Descriptive Analyses

The basic quantitative information that the descriptive analyses provided will allow us to select texts that meet highly specific minimum, maximum and central tendency criteria for sentence length and paragraph length. These basic descriptive criteria differed between mathematics selections and science and social studies selections though not between the latter two. Mathematics sentences were a couple of words shorter on average than either science or social studies at 13 and 14 words respectively. The range between the minimum and maximum number of words per sentence was greatest for social studies, but sentence lengths for all three subjects ranged close to 1-40 words. Math word problems were 1 sentence shorter on average than the science and social studies paragraphs that averaged 4 sentences. These fundamental differences can be used to guide the selection of overall text length and sentence composition in the development of test items

Implications From Lexical Analyses

There are a number of implications for test development that lexical-level analyses have generated and warrant enumerating and summarizing in further detail here.

1. In general, the mathematics texts we analyzed were quite different from both science and social studies texts; science texts had the highest proportion of general and specialized academic words; social studies texts were the most complex in terms of demanding vocabulary (e.g.,

highest lexical diversity ratio, highest proportions of content-related proper nouns, 3-or-more- syllable words, derived words, and a number of different types of clause connectors.)

2. The relatively uniform findings across the different topics within subjects for most of the lexical features we examined support the use of these features for later subject-area generalizations in test development (e.g., selecting texts that mirror these lexical characteristics).
3. A striking observation with implications for test development includes the contrast between rare uses of some words and the highly repetitive use of a small set of other words often found across all three subject areas (e.g., certain prepositions, determiners, and conjunctions). From a test development perspective, we might attempt to avoid words that are rarely used if the construct we wish to measure is general academic use of language, focusing instead on the vocabulary that forms a core of "must-know" words.
4. Given that derived word forms occur in relatively low numbers across the subjects, we should attempt to avoid the selection of texts with large or inordinate numbers of such words for use in test development because they do not represent the norm. However, it should be noted that derived forms best account for words identified as academic vocabulary in all subjects, impressively so in the areas of science and social studies. Derivational formation of words can, therefore, help to identify academic vocabulary more systematically than any of the other lexical features we examined here, at least at the fifth-grade level.
5. The relatively few similarities in academic words used across subject-areas (just 15 academic words in common), especially the infrequent use of general academic vocabulary, suggest that test developers still need to pay close attention to the individual characteristics of each subject area and to the particularities of individual texts selected for assessment purposes. Test developers are thus faced with striking a balance between the adoption of a census approach (i.e., assess every feature) in order to capture the full range of vocabulary in all academic settings, and the sampling of a restricted number of general academic words shared across subject areas in much greater depth.

Implications From Grammatical Analyses

The grammatical analyses reported here were selected based on our previous exploratory work (Butler et al., 2004) and the literature that identified a number of grammatical features (e.g., passive voice verb forms) to be hallmarks of academic texts. Some of the analyses, however, may have been focused at too demanding a language level for typical fifth-grade textbooks in that use of passive voice verb forms and past and present participial modifiers, for example, was minimal in the selections in all three subject areas. While these features should not be a focus for test development at this level, tracking their presence is important for establishing an academic language trajectory. At the level of the clause and sentence, on the other hand, a small number of measures of length and frequency suggest important differences and commonalties across subjects that will need to be taken into account for test development purposes.

1. While all subject-area texts in this study have a greater number of simple sentences than complex sentences, the mathematics texts consist almost exclusively of simple sentences, with science and social studies texts containing closer to a 60/40 split between simple and complex sentences. Texts selected for use on academic language proficiency reading tests should reflect these tendencies.
2. Sentences in the three subjects are composed of the same number of phrase types: both prepositional and noun phrases are distributed comparably in mathematics, science and social studies with each sentence containing just one prepositional phrase and three noun phrases on average. Similarities also extend to the length of these phrase types. This information could be used for item specifications in test development. This finding, however, is surprising given that science and social studies texts containing longer sentences and prepositional phases are generally thought to contribute to increased sentence length. This suggests that sentence length in science and social studies is likely attributable to other grammatical structures that increase sentence length, such as embedded clauses (e.g., relative clauses). Finer discrimination among clause types should be included in future profiles of texts.
3. A number of grammatical features that were investigated in this study may only become characteristic of print academic language in later grades, and this finding can be taken into consideration by largely avoiding such grammatical features when selecting texts and creating items appropriate for the fifth-grade level. However, given the relative greater prevalence of these features already in science and social studies at the fifth-grade, we might predict from the current findings that these subject areas will be more likely than mathematics texts to contain these features at the higher grades.

Implications From Organizational Features Analyses

Ultimately, the organization of texts pulls the other analyses mentioned above together under the same umbrella because most features, whether grammatical or lexical, interact within the organizational structure of texts. The implications of this are multifold, beginning with the need to link relevant features with text organization features; for example, students must recognize comparative adjectives in order to understand that a comparison is being made. In addition, the different features must be tested in their contexts of use. As shown in Chapter 5, for example, many supporting organizational features are embedded within dominant features occurring mostly at the sentence level; however, the most frequently occurring supporting features (e.g., *comparison*, *sequencing*, etc.) occur in a greater variety of contexts. Establishing the relationships between grammatical and lexical features, as well as understanding the typical contexts of use for features at a particular grade level and subject area, enables test developers to organize the content of tests in meaningful ways. Indeed, test organization should reflect language in use, not discrete points of language divorced from context.

1. Specific areas of concern for test developers include the differences in text organization across subject areas. In our research we found that science and social studies texts make broader use of a range of organizational features than mathematics.[25] Frequently used features shared by these two subject areas must be considered for general tests of academic language proficiency since these subject areas reflect a more substantial portion of students' reading loads, as opposed to mathematics word problems.
2. Conversely, areas of overlap across the three subject areas indicate core features that students must be able to recognize and interpret in the texts they read across subject areas. These features include *comparison*, *description*, *enumeration*, *paraphrase*, and *sequencing*. Texts selected for test development should reflect these features, and test items should tap students' abilities to grasp the meaning and purpose of the features in a given text.

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[25] The absence of some organizational features in mathematics textbooks may unfortunately be consistent with the recent concerns of mathematicians who have called for the greater use of *generalization* and inclusion of proofs in mathematics education (e.g., Schoenfeld, 1994; Kaput, Schoenfeld, and Dubinsky, 1996). Word problems would seem to be particularly well positioned to allow for the generalization of mathematical concepts across contexts and it is hoped that textbook writers (following reformed content standards) could make use of this opportunity in the future.

3. Our research also points to the complexity of many of the organizational features; for example, *definition* is provided in multiple ways: through traditional *definition* (e.g., *a dog is a type of animal*), through *labeling* (e.g., *one type of popular domestic animal is called a dog*), through *paraphrase* (e.g., *a type of popular pet, dogs, can be found in most American homes*), and *classification (e.g., a chihuahua, a cocker spaniel, and a boxer are all dogs*). Comparisons are made for the purpose of describing, explaining, and exemplifying. Test developers should consider the multiple layers of occurrence with text features when creating test specifications and subsequently when writing test items. Many of these complexities in language represent levels of language proficiency, (i.e., some subtleties of the features may be understood and produced more frequently at lower levels of proficiency, while others may be more commonly used by advanced level ELs).
4. Another area of interest for test developers identified in the current research is the frequent use of features that assist students with their reading (e.g., *paraphrase*, *providing instruction or guidance*, and *references to other text or visuals*). As mentioned in Chapter 6, these features are used in oral classroom contexts as well by teachers when they present and explain academic material. Therefore, test developers should consider the inclusion of items that tap students' ability to understand when assistance is being offered and whether students are able to use that assistance effectively.

Additional Implications

A potentially useful extension of our work is to inform test developers in the content areas. As they develop tests of mathematics, science and social studies content, these tests developers should also consider the appropriate language level for their items. Research of the type reported here provides empirical grade-level information that can inform test development decisions. Along similar lines, the findings reported here can be utilized by textbook and curriculum developers as well as professional development programs in order to typify the level of language demand EL students are expected to master for the successful reading of subject-area material.

Methodological Ramifications

Number of Text Selections per Subject Area

The number of text selections in this study, while limited from a quantitative perspective, provided a rich data source for the type of descriptive and basic inferential statistical analyses conducted. The text selection process we devised to facilitate in-depth linguistic analyses, meant that for science and social studies we deliberately chose to maintain text selections in their topic entirety rather than take a census of a larger number of randomly sampled single paragraph selections across the textbooks. While a census may have been amenable to the mathematics textbook format, in which there are few discourse-level organizational features, restricting the data to a large number of unrelated paragraphs would not have allowed for the characterization of text features that capture rhetorical devices and language functions, for example, in science and social studies.

The linguistic analyses in this study were labor intensive and were part of the development of a process for characterizing the academic language used in textbooks. Now that a process is in place with specific guidelines for the analyses, future work across grade levels can be carried out more efficiently and should allow for the use of larger numbers of text selections. The data will then be amenable to more sophisticated inferential and other statistical techniques.

Incorporation of Additional Grammatical Features

The grammatical analyses conducted in this research have focused primarily on those English language structures that the literature suggested would be most challenging for English learners reading English texts (e.g., passive constructions, participial modifiers). While few constructions of these types appeared in any frequency in the fifth-grade textbooks we analyzed, documenting the limited emergence of these features at the fifth grade will be important in establishing cross-grade level developmental markers for academic English. For future analyses at this and earlier grade levels, however, we suggest beginning with a comprehensive descriptive analysis of the grammatical features evident in the texts. Analyses of texts in terms of more basic and commonly occurring grammatical structures such as simple and complex declarative forms, interrogative forms, negative forms, and description of tense and aspect will help ensure a more comprehensive grammatical characterization of the texts.

Next Steps

Prototype Task Development

Future CRESST work will focus on utilizing the linguistic profiles for creating test specifications, including guidelines for text selection and prototype task/item writing. As mentioned in Chapter 6, once it has been determined that a text and associated tasks fit into the parameters established in the current research, they will undergo both internal and external reviews by curriculum and/or language experts and subject area teachers. External reviews will provide a combination of focus group data and questionnaire data and will include a sensitivity review (to detect biases in terms of gender, race, etc.), a text and item review to assure that the texts and items are topically and linguistically representative of the types that teachers typically use in their classrooms, and a language review to catch any additional linguistic anomalies or concerns that may exist. Based on this feedback texts will be retained or rejected, and items can be either rejected or modified based on the review.

Extension to Additional Grade Levels

The results of the analyses have implications for applications of the research methodology to different grade levels or grade clusters, particularly higher grade levels where textbooks may include far greater amounts of such lexico-grammatical features as nominalizations, greater numbers of and diversity in clausal connectors, passive verb constructions, prepositional phrases, and participial modifiers. For example, we expect that the use of passive voice verb forms will increase with each grade level; however, currently we do not have empirical evidence showing at which grade the comprehension and use of passive voice becomes critical for young readers, as well as whether there are frequency differences among subclassifications of passive constructions at different grade levels. Research such as this will lead to the identification of trajectories of language use by grade level and in each subject area, valuable not only in testing but also in materials and curriculum development and professional development.

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APPENDIX A

Example Texts from Mathematics,
Science, and Social Studies

Mathematics Texts

A large can of juice contains 1.5 liters and sells for $2.09. A smaller can of the same juice contains 750 milliliters and sells for $0.98. Which is the better buy? (Remember: There are 1000 milliliters in 1 liter).[26]

Willoughby et al., 2003, p. 268

The Last Federal Trust Company pays $0.06 for each dollar that you keep in a savings account for a year. If you keep $250 in a savings account there for one year, how much will they pay you?[27]

Willoughby et al., 2003, p. 86

When a new video game was released, a large toy store sold twice as many games on the 1st day as on the 4th day. On the 3rd day, they sold 134 games. On the 2nd day, they sold 27 more games than on the 3rd day and 52 less than on the 4th day. How many games were sold on the 1st day?[28]

Greenes et al., 2002, p. 541

[26] Text excerpt from Willoughby et al., SRA/McGraw-Hill Mathematics, Grade 5. Copyright © 2003 by SRA/McGraw-Hill Companies. Reproduced with permission of The McGraw-Hill Companies.

[27] Text excerpt from Willoughby et al., SRA/McGraw-Hill Mathematics, Grade 5. Copyright © 2003 by SRA/McGraw-Hill Companies. Reproduced with permission of The McGraw-Hill Companies

[28] Text from Houghton-Mifflin Mathematics, Grade 5 Student Book. Copyright © 2002 by Houghton-Mifflin Company. Reprinted by permission of the publisher. All rights reserved.

What if Jessica's tower was 11/12 yard after 3 weeks? This was 1/6 yard taller than it was after 2 weeks. The height at 2 weeks was 1/4 yard taller than it was after the first week. How tall was the tower after the first week?[29]

Maletsky et al., 2001, p. 327

[29] From *HARCOURT MATH*, Grade 5, Student Edition. Copyright © by Harcourt, Inc. Included by permission of the publisher.

Science Text

Measuring Mass and Volume

It's a cold day, and you and a friend are standing at a bus stop. You've been shopping, and you each have a package to hold. One package is quite heavy; the other is lighter but is larger and more bulky. Which package would you choose to hold?

Like everything around you, the packages are made up of matter. Matter is anything that has mass and volume. In fact, the problem of which package is easier to hold involves these two physical properties—mass and volume. As seen in the activities on pages C6 to C8, these properties can be measured. To review and practice your skills for measuring these and other properties, read pages H6 to H9 in the Science and Math Toolbox.

The heaviness of each package is directly related to its mass. Mass is a measure of how much matter something contains. Weight is a measure of the force of gravity acting on a mass. So the more matter an object contains—the greater its mass—the more it will weigh.

A spring scale, which is used to weigh objects, measures the effect of gravity on an object. To find an object's mass, you have to use a balance, like the one shown on page C11.

The most common metric units used to measure are grams (g) and kilograms (kg). A penny has a mass of about 2 g. A kilogram is one thousand times the mass of a gram. A large cantaloupe has a mass of about 1 kg.

Other units are also used for measuring mass in the metric system. For example, the mass of a very light object could be measured in milligrams (mg). One milligram is equal to one thousandth (1/1000) of a gram.

The volume of an object is the amount of space it takes up. For example, an inflated balloon takes up more space—has greater volume—than an empty balloon. Volume can also be used to express capacity—that is, how much material something can hold. A swimming pool can hold a lot more water than a teacup can.

The basic unit of volume in the metric system is the cubic meter (m3). But because 1 m3 is such a large amount, the liter (L) is more commonly used. A liter is slightly larger than a quart. Many soft drinks are sold in 2-L containers. Units used to measure smaller volumes include the centiliter (cL), which is one hundredth of a liter, and the milliliter (mL), which is one thousandth of a liter.

A graduated cylinder, which is often called a graduate, is used to measure liquid volumes. Using a graduate is similar to using a measuring cup.

Suppose you want to know how much water or some other liquid is in a container of some kind. First you pour the liquid from the container into a graduate. Then you measure the level of the liquid against the scale marked on the side of the graduate.

There are two methods for finding the volume of a solid. One method is used for finding volumes of solids that have regular geometric shapes, such as cubes, spheres, and rectangular blocks. For any solid with a regular shape, you can measure such dimensions as length, width, height, and diameter. Then you can calculate the volume of the solid by substituting the measurements in a mathematical formula. For example, the volume of a rectangular block can be found by multiplying its length times its width times its height. The formula for this calculation is below. V=1 x w x h.

Many solids do not have a regular shape. A rock, for example, is likely to have an irregular shape. The volume of these kinds of solids can be found by using the water displacement method.

Suppose you want to use the water displacement method to find the volume of a rock, such as the one shown in the picture. The first step is to find a graduate large enough to hold the rock. Next, you fill the graduate about one-third full with water. Then you lower the rock into the graduate, as shown.[30]

Badders et al., 2000, pp. C10-C12

[30] Text from Houghton-Mifflin Science: Discovery Works, Grade 5 Student Book.

Social Studies Text

The Industrial Revolution

The new machine that Nathan Appleton described had been invented in Great Britain. In the late 1700s British inventors and businesses brought about the changes in industry and technology that became known as the Industrial Revolution. The Industrial Revolution changed the way goods were made. Goods that had been made by hand in homes or workshops were now made by machines, often in factories.

Before the Industrial Revolution, women and children slowly spun yarn and wove cloth by hand. The first British factories used water-powered machines to spin cotton yarn and weave cloth. After the Industrial Revolution, production increased and costs decreased.

At the time of Britain's Industrial Revolution, the young United States was still mainly a land of farms. Before long, though, a British mechanic named Samuel Slater would bring the Industrial Revolution to the United States. His yarn-spinning machine would come to represent the beginning of a new way of life for our country.

Because of the Industrial Revolution, no other country in the world could make cloth as cheaply as Great Britain. The British wanted to keep their profitable technology a secret. So they passed laws making it illegal to export machines or machine plans. The people who operated machines in cotton factories were not even allowed to leave the country.

In 1789 Samuel Slater memorized the plans of the British spinning machines. He had heard that, because of the free market in the United States, business owners there would pay for this new technology. In a free market, producers of goods and services freely decide how to use resources in response to demand. People in the United States wanted to start their own business in making cloth.

Slater slipped out of the country and came to the United States. Soon he was hired by a merchant to build spinning machines in Rhode Island. By 1790 Slater had built the first American machines to spin cotton into yarn.

Slater had to pay a high price for the cotton he used in his factory, which limited his profits. In 1793, however, an American inventor built a machine that made cotton cheaper to produce. His name was Eli Whitney.

Whitney heard planters talk about how long it took enslaved workers to remove the stubborn seeds stuck to cotton. Whitney invented the cotton gin in ten days. Whitney's gin, which is short for "engine," helped workers clean up to 50 times more cotton than they could by hand.

As you can see from the bar graph below, cotton production boomed after the invention of the cotton gin. Together, slave labor and the cotton gin made growing cotton more profitable. Many planters became more determined to keep slavery alive.

The cotton gin helped create a plentiful supply of cotton. However, the United States did not have Great Britain's water-powered machines, called "power looms." The looms wove cloth more quickly and cheaply than Slater's machines.

Like Samuel Slater and Eli Whitney, Francis Cabot Lowell helped spread the Industrial Revolution in the United States. In 1810 Lowell, a New England merchant, toured several cloth-making factories in Great Britain. He decided to build a factory of his own. In 1813 Lowell and his partners built our country's first power loom, in Waltham, Massachusetts. For the first time all stages of cloth-making—from spinning cotton into thread to weaving yarn into cloth—happened under one roof.

The swift waters of the Charles River powered the machines. The diagram on the next page shows how the water-wheel spun big leather belts. The belts, in turn, kept the machines moving.

Lowell died in 1817, but his business partners later built several textile mills next to the Merrimack River in Massachusetts. They also built a town, which they called Lowell, around the mills for the workers. It was the first planned town for workers to be built in the United States.

Mostly unmarried women between the ages of 15 and 19 worked at the mills in Lowell and other towns. Few jobs were open to women then. Therefore, many were glad to get the work, although they had long and tiring days.

The women from New England who worked at Lowell were called "mill girls." They lived in boarding houses built by the mill owners. In their spare time, the women attended lectures and reading clubs. Some also wrote poetry and stories for the Lowell Offering, a magazine published by the mill girls.

A mill girl spent 12 to 14 hours a day working at her machine, six days a week. The noise was often deafening. Lucy Larcom complained of "the buzzing and hissing pulleys and rollers and spindles." Read the following excerpt from a Lowell mill girl's letter home to her father. What rule did she have to follow? Why do you think that rule was important?[31]

Banks et al., 2001, pp. 404-406

[31] Text excerpt from Banks et al., McGraw-Hill United States: Adventures in Time and Place, Grade 5.

APPENDIX B

Academic Words Common across All Three Subject Area Selections

contained

continued

equal (adjective)

example

explains

express (verb)

in order to[*]

increase (verb)

km (kilometer)

population

pound (weight)

produce (verb)

products

separate

suppose

APPENDIX C

The Twenty Most Frequently Occurring Words by Subject Area

Mathematics		*Science*		*Social Studies*	
Word	No. of Occurrences	Word	No. of Occurrences	Word	No. of Occurrences
the	410	*the*	585	*the*	857
of	258	*a*	244	*to*	355
a	187	*of*	236	*of*	286
to	154	*is*	185	*and*	277
how	145	*and*	154	*in*	261
in	118	*in*	150	*a*	229
and	114	*to*	147	*they*	127
is	112	*water*	144	*were*	125
for	112	*are*	74	*was*	125
each	83	*as*	74	*had*	105
she	76	*can*	71	*for*	93
he	75	*that*	70	*their*	91
on	67	*on*	60	*that*	90
much	60	*an*	53	*he*	82
was	59	*you*	52	*on*	75
what	58	*from*	52	*by*	64
many	51	*or*	51	*as*	64
did	45	*it*	50	*from*	63
about	44	*this*	47	*people*	62
if	43	*mass*	45	*or*	53

APPENDIX D

Clause Connectors across Subject Areas

Adverbial dependent clause connectors:	Mathematics	Science	Social Studies
after	x	x	x
(al)though		x	x
as		x	x
as if			x
because		x	x
before	x	x	x
even before			x
even though		x	x
ever since		x	
if	x	x	x
once		x	
since		x	x
so	x	x	x
so that	x		x
until		x	x
when	x	x	x
where		x	
whether			x
while	x	x	x
Coordinate clause connectors:			
and	x	x	x
but	x		x
or	x	x	x
nor	x		x

APPENDIX E

Sentence Types

Aggregate Counts of Sentence Types in Subject Areas by Topic

Table E1

Aggregate Counts of Sentence Types in Mathematics by Topic

	Topic Totals				
Statistics	*Decimals*	*Fractions*	*Multiplication*	*Ratio*	Area Total
Simple	143	130	130	128	531
Complex	21	30	30	30	111
Compound	2	5	1	2	10
Compound/complex	1	0	1	0	2
% of total that are simple	85.62	78.79	80.25	80.00	81.19
% of total that are complex	12.57	18.18	18.52	18.75	16.97
% of total that are compound	1.20	3.03	0.62	1.25	1.53
% of total that are compound/complex	0.60	0.00	0.62	0.00	0.31

Table E2

Aggregate Counts of Sentence Types in Science by Topic

	Topic Totals				
Statistics	*Matter*	*Plants*	*Storms*	*Water Cycle*	Area Total
Simple	84	104	86	77	351
Complex	57	48	48	47	200
Compound	4	2	3	1	10
Compound/complex	1	0	4	0	5
% of total that are simple	57.53	67.53	60.99	61.60	62.01
% of total that are complex	39.04	31.17	34.04	37.60	35.34
% of total that are compound	2.74	1.30	2.13	0.80	1.77
% of total that are compound/complex	0.68	0.00	2.84	0.00	0.88

Table E3

Aggregate Counts of Sentence Types in Social Studies by Topic

Statistics	Topic Totals				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Total
Simple	85	138	156	139	518
Complex	81	57	56	64	258
Compound	3	4	3	13	23
Compound/complex	3	0	1	6	10
% of total that are simple	49.42	69.35	72.22	62.61	64.03
% of total that are complex	47.09	28.64	25.93	28.83	31.89
% of total that are compound	1.74	2.01	1.39	5.86	2.84
% of total that are compound/complex	1.74	0.00	0.46	2.70	1.24

Topic Averages for Sentence Types in Subject Areas

Table E4

Topic Averages for Sentence Types in Mathematics

Statistic	Topic Averages				
	Decimals	*Fractions*	*Multiplication*	*Ratio*	Area Average
Simple	47.67	43.33	43.33	42.67	44.25
Complex	7.00	10.00	10.00	10.00	9.25
Compound	0.67	1.67	0.33	0.67	0.83
Compound/complex	0.33	0.00	0.33	0.00	0.17
% of total that are simple	86.10	78.87	78.93	0.80	80.95
% of total that are complex	11.91	18.09	19.62	0.19	17.14
% of total that are compound	1.25	3.04	0.72	0.01	1.54
% of total that are compound/complex	0.74	0.00	0.72	0.00	0.37

Table E5

Topic Averages for Sentence Types in Science

Statistic	Topic Averages				
	Matter	*Plants*	*Storms*	*Water Cycle*	Area Average
Simple	28.00	34.67	28.67	25.67	29.25
Complex	19.00	16.00	16.00	15.67	16.67
Compound	1.33	0.67	1.00	0.33	0.83
Compound/complex	0.33	0.00	1.33	0.00	0.42
% of total that are simple	56.99	66.62	60.52	61.42	61.39
% of total that are complex	39.70	31.98	34.11	37.51	35.83
% of total that are compound	2.65	1.39	2.16	1.08	1.82
% of total that are compound/complex	0.65	0.00	3.21	0.00	0.96

Table E6

Topic Averages for Sentence Types in Social Studies

Statistic	Topic Averages				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
Simple	28.33	46	52	46.33	43.17
Complex	27.00	19	18.67	21.33	21.5
Compound	1.00	1.33	1	4.33	1.92
Compound/complex	1.00	0	0.33	2	0.83
% of total that are simple	48.41	68.82	71.31	62.11	62.66
% of total that are complex	46.81	28.60	26.80	28.81	32.76
% of total that are compound	1.89	2.11	1.41	6.01	2.86
% of total that are compound/complex	1.71	0.00	0.47	2.96	1.28

APPENDIX F

Clause Types

Aggregate Counts of Clause Types in Subject Areas by Topic

Table F1

Aggregate Counts of Clauses in Mathematics by Topic

Statistic	Topic Totals				
	Decimals	*Fractions*	*Multiplication*	*Ratio*	Area Total
No. of sentences	167	165	162	160	654
No. of clauses	234	222	223	233	912
No. of dep. clauses	60	55	60	67	242
Dependent clauses as a % of total clauses	25.64	29.77	26.91	28.76	26.54
No. of coord. clauses	7	2	1	6	16
Coordinate clauses as a % of total clauses	2.99	0.90	0.45	2.58	1.75

Table F2

Aggregate Counts of Clauses in Science by Topic

Statistic	Topic Totals				
	Matter	*Plants*	*Storms*	*Water Cycle*	Area Total
No. of sentences	146	154	141	125	566
No. of clauses	219	211	208	186	824
No. of dep. clauses	67	55	60	60	242
Dependent clauses as a % of total clauses	30.59	26.07	28.85	32.26	29.37
No. of coord. clauses	6	2	7	1	16
Coordinate clauses as a % of total clauses	2.74	0.95	3.37	0.54	1.94

Table F3

Aggregate Counts of Clauses in Social Studies by Topic

Statistic	Topic Totals				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Total
No. of sentences	174	200	216	222	812
No. of clauses	298	269	291	329	1187
No. of dep. clauses	116	65	69	89	339
Dependent clauses as a % of total clauses	38.93	24.16	23.71	27.05	28.56
No. of coord. clauses	8	4	6	18	36
Coordinate clauses as a % of total clauses	2.68	1.49	2.06	5.47	3.03

Topic Averages for Clause Types in Subject Areas

Table F4

Topic Averages for Clauses in Mathematics

Statistic	Topic Averages				
	Decimals	*Fractions*	*Multiplication*	*Ratio*	Area Average
No. of sentences	55.67	55.00	54.00	53.33	54.50
No. of clauses	78.00	74.00	74.33	77.67	76.00
No. of dep. clauses	20.00	18.33	20.00	22.33	20.17
Dependent clauses as a % of total clauses	25.66	24.92	26.99	28.07	26.41
No. of coord. clauses	2.33	0.67	0.33	2.00	1.33
Coordinate clauses as a % of total clauses	3.20	0.94	0.50	2.75	1.85

Table F5

Topic Averages for Clauses in Science

Statistic	Topic Averages				
	Matter	*Plants*	*Storms*	*Water Cycle*	Area Average
No. of sentences	48.67	51.33	47.00	41.67	47.17
No. of clauses	73.00	70.33	69.33	62.00	68.67
No. of dep. clauses	22.33	18.33	20.00	20.00	20.17
Dependent clauses as a % of total clauses	30.16	26.29	28.87	32.41	29.43
No. of coord. clauses	2.00	0.67	2.33	0.33	1.33
Coordinate clauses as a % of total clauses	2.81	0.97	3.51	0.64	1.98

Table F6

Topic Averages for Clauses in Social Studies

Statistic	Topic Averages				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
No. of sentences	58.00	66.67	72	74	67.67
No. of clauses	99.33	89.67	97	109.667	98.92
No. of dep. clauses	38.67	21.67	23	29.6667	28.25
Dependent clauses as a % of total clauses	38.98	24.24	23.76	26.95	28.49
No. of coord. clauses	2.67	1.33	2	6	3
Coordinate clauses as a % of total clauses	2.71	1.52	1.98	5.51	2.93

APPENDIX G

Topic Averages for Passives in Subject Areas

Table G1

Topic Averages for Passives in Mathematics

Statistic	Topic Averages				
	Decimals	*Fractions*	*Multiplication*	*Ratios*	Area Average
No. of clauses	69.33	70.33	62.00	73.00	68.67
No. of sentences	55.67	55.00	54.00	53.33	54.50
No. of passive voice verb forms	0.67	3.33	2.67	2.67	2.33
No. of passive voice verb forms per clause	0.01	0.05	0.04	0.04	0.03
No. of passive voice verb forms per sentence	0.01	0.06	0.05	0.05	0.04

Table G2

Topic Averages for Passives in Science

Statistic	Topic Averages				
	Matter	*Plants*	*Storms*	*Water Cycle*	Area Average
No. of clauses	73.00	70.33	69.33	62.00	68.67
No. of sentences	48.67	51.33	47.00	41.67	47.17
No. of passive voice verb forms	14.33	12.33	6.00	12.00	11.17
No. of passive voice verb forms per clause	0.20	0.17	0.09	0.19	0.16
No. of passive voice verb forms per sentence	0.29	0.24	0.13	0.30	0.24
No. of passive "by" phrases	0.00	3.33	0.00	3.00	1.58
% of clauses with "by" phrases	0.00%	4.65%	0.00%	4.79%	2.36%
% of passive voice verb forms that include "by" phrases	0.00%	29.28%	0.00%	19.52%	12.20%
No. of passive "by" phrases per sentence	0.00	0.06	0.00	0.08	0.03

Table G3

Topic Averages for Passives in Social Studies

Statistic	Topic Averages				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
No. of clauses	99.33	89.67	97.00	109.67	98.92
No. of sentences	58.00	66.67	72.00	74.00	67.67
No. of passive voice verb forms	10.00	9.67	8.67	15.33	10.92
No. of passive voice verb forms per clause	0.10	0.11	0.09	0.14	0.11
No. of passive voice verb forms per sentence	0.17	0.14	0.12	0.20	0.16
No. of passive "by" phrases	0.33	0.33	2.33	1.33	1.08
% of clauses with "by" phrases	0.31%	0.42%	2.23%	1.19%	1.09%
% of passive voice verb forms that include "by" phrases	1.85%	4.17%	20.24%	8.75%	9%
No. of passive "by" phrases per sentence	0.01	0.01	0.03	0.02	0.02

APPENDIX H

Topic Averages for Prepositional Phrases in Subject Areas

Table H1
Topic Averages for Prepositional Phrases in Mathematics

	Topic Averages				
Statistic	*Decimals*	*Fractions*	*Multiplication*	*Ratio*	Area Average
No. of pps*	58.33	68.33	49.00	63.00	59.67
No. of words in pps	187.33	204.67	159.00	316.00	216.75
Min no. of words in pp	2.00	2.00	2.00	2	2
Max no. of words in pp	9.33	6.00	7.33	9	9
Mean no. of words in pps	3.19	2.98	3.26	4.89	3.58
SD of no. of words in pps	1.44	1.01	1.15	1.48	1.27
Words in pps as % of words	31.46%	35.41%	28.91%	50.69%	36.62%
Mean no. of pps per clause	0.84	0.97	0.81	0.87	0.87
Mean no. of pps per sentence	1.07	1.24	0.91	1.19	1.10

*pps=prepositional phrases

Table H2
Topic Averages for Prepositional Phrases in Science

	Topic Averages				
Statistic	*Matter*	*Plants*	*Storms*	*Water Cycle*	Area Average
No. of pps*	68.67	72.33	52.33	68.00	65.33
Words in pps	282.33	287.67	230.00	261.67	265.42
Min no. of words in pp	2.00	2.00	2.00	2.00	2.00
Max no. of words in pp	14.67	11.00	10.33	11.67	11.92
Mean no. of words in pps	4.11	4.00	4.40	3.85	4.09
SD of no. of words in pps	2.52	1.85	2.07	3.15	2.40
Words in pps as % of words	41.89%	44.56%	40.36%	49.59%	44.10%
Mean no. of pps per clause	0.94	1.03	0.76	1.13	0.97
Mean no. of pps per sentence	1.41	1.43	1.14	1.72	1.42

*pps=prepositional phrases

Table H3
Topic Averages for Prepositional Phrases in Social Studies

Statistic	Topic Averages				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
No. of pps*	93.00	97.00	99.33	99.67	97.25
No. of words in pps	343.67	351.67	374.67	385.67	363.92
Min no. of words in pp	2	2	2	2	2.00
Max no. of words in pp	12	11	15	20	20.00
Mean no. of words in pps	3.69	3.63	3.77	3.88	3.74
SD of no. of words in pps	1.96	1.88	2.09	2.32	1.87
Words in pps as % of words	41.09%	39.11%	41.85%	39.28%	40%
Mean no. of pps per clause	0.94	1.08	1.03	0.92	0.99
Mean no. of pps per sentence	1.62	1.46	1.40	1.36	1.46

*pps=prepositional phrases

APPENDIX I

Topic Averages for Noun Phrases in Subject Areas

Table I1
Topic Averages for Noun Phrases in Mathematics

	Topic Averages				
Statistic	*Decimals*	*Fractions*	*Multiplication*	*Ratio*	Area Average
No. of nps*	186.67	169.67	157.00	163.67	169.25
No. of words in nps	399.33	393.67	372.67	447.33	403.25
Min no. of words in np	1.00	1.00	1.00	1.00	1.00
Max no. of words in np	8.33	9.67	9.67	12.00	9.92
Mean no. of words in nps	2.12	2.33	2.38	2.80	2.41
SD of no. of words in nps	1.34	1.62	1.47	2.13	1.64
Mean no. of nps per clause	2.70	2.41	2.61	2.24	2.49
Mean no. of nps per sentence	3.41	3.10	2.95	3.06	3.13

*nps=noun phrases

Table I2
Topic Averages for Noun Phrases in Science

	Topic Averages				
Statistic	*Matter*	*Plants*	*Storms*	*Water Cycle*	Area Average
No. of nps*	141.67	158.67	111.67	132.33	136.08
No. of words in nps	453.33	433.67	373.00	343.00	400.75
Min no. of words in np	1.00	1.00	1.00	1.00	1.00
Max no. of words in np	14.67	17.33	13.33	12.33	14.42
Mean no. of words in nps	3.20	2.74	3.41	2.63	3.00
SD of no. of words in nps	2.84	2.22	2.77	2.31	2.54
Mean no. of nps per clause	1.95	2.26	1.62	2.14	1.99
Mean no. of nps per sentence	2.92	3.12	2.39	3.21	2.91

*nps=noun phrases

Table I3
Topic Averages for Noun Phrases in Social Studies

Statistic	Topic Averages				
	Declaration of Independence	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
No. of nps*	206.00	216.33	210.33	240.33	218.25
No. of words in nps	544.67	611.00	555.67	636.33	586.92
Min no. of words in np	1.00	1.00	1.00	1.00	1.00
Max no. of words in np	13.33	14.00	15.33	14.67	14.33
Mean no. of words in nps	2.67	2.82	2.64	2.66	2.70
SD of no. of words in nps	2.19	2.44	2.20	2.24	2.27
Mean no. of nps per clause	2.07	2.41	2.19	2.19	2.22
Mean no. of nps per sentence	3.55	3.25	2.97	3.26	3.26

*nps=noun phrases

APPENDIX J

Topic Averages for Participial Modifiers in Subject Areas

Table J1

Topic Averages for Participial Modifiers in Mathematics

	Topic Averages				
Statistic	*Decimals*	*Fractions*	*Multiplication*	*Ratio*	Area Average
No. of words in selection	596.00	572.00	550.00	618.00	584.00
No. of sentences	56	55	54	53	54.50
Frequency of Participial Modifiers					
Present	1.00	0.67	0.67	0	0.58
Past	1.00	0.33	1.67	1.00	1.00
All participials	2.00	1.00	2.33	1.00	1.58
Frequency of Participial Modifiers per sentence					
Present	0.02	0.01	0.01	0	0.01
Past	0.02	0.01	0.03	0.02	0.02
All participials	0.04	0.02	0.04	0.02	0.03
Participial Modifiers as % of total words					
Present	0	0	0	0	0
Past	0	0	0	0	0
All participials	0	0	0	0	0

Table J2

Topic Averages for Participial Modifiers in Science

Statistic	*Matter*	*Plants*	*Storms*	*Water Cycle*	Area Average
	Topic Averages				
No. of words in selection	2018	646	570	531	605.08
No. of sentences	146	51	47	42	47.17
Frequency of Participial Modifiers					
Present	4	2	5	5	3.25
Past	21	5	2	4	4.42
All participials	25	6	8	8	7.67
Frequency of Participial Modifiers per sentence					
Present	0.03	0.04	0.12	0.12	0.07
Past	0.14	0.10	0.05	0.08	0.09
All participials	0.17	0.14	0.17	0.19	0.17
Participial Modifiers as % of total words					
Present	0	0	0.01	0.01	0.01
Past	0.01	0.01	0	0.01	0.01
All participials	0.01	0.01	0.01	0.02	0.01

Table J3

Topic Averages for Participial Modifiers in Social Studies

Statistic	*Declaration of Independence*	*Industrial Revolution*	*Pilgrims*	*Slavery*	Area Average
	Topic Averages				
No. of words in selection	842.67	901.33	705.25	985.67	906.50
no. of sentences	58.00	66.67	59.75	74.00	67.67
Frequency of Participial Modifiers					
Present	2.33	5.67	3.00	5.67	4.33
Past	1.33	6.67	5.00	15.67	7.42
All participials	3.67	12.33	7.75	21.33	11.75
Frequency of Participial Modifiers per sentence					
Present	0.04	0.09	0.05	0.07	0.06
Past	0.02	0.10	0.09	0.20	0.10
All participials	0.06	0.19	0.14	0.28	0.17
Participial Modifiers as % of total words					
Present	0	0.01	0	0.01	0
Past	0	0.01	0.01	0.02	0.01
All participials	0	0.01	0.01	0.02	0.01

APPENDIX K

Glossary of Organizational Features:
Terms, Definitions, and Examples[32]

The glossary is divided into two sections: dominant and supporting features, and mathematics task features. The mathematics task features list consists of only those features unique to mathematics tasks (e.g., writing a problem statement). Terms are listed alphabetically in each section, followed by a definition and at least one example. If an outside source was consulted for the definition, the source is cited next to it. The following sources (and their abbreviations) were used in developing the definitions: *Cambridge International Dictionary* (CID) (2001); *Content Area Reading* (CAR) (Vacca & Vacca, 1996); and *The Random House College Dictionary* (RHCD) (1988). Additionally, prior CRESST research was consulted and is cited if applicable. If no source is cited, the term was defined by the authors for the purposes of this report.

Dominant and Supporting Text Features

Analogy:

"A partial similarity between like features of two things, on which a comparison may be based: *the analogy between a heart and a pump*" (RHCD, p. 48). In the example below, an analogy is created between the amount of salt water on earth and the amount that would be contained in a similarly proportioned 1-liter bottle.

> Example:
> As you saw in the last lesson, most of the water on Earth is salt water. Suppose that all of the Earth's water just fills a 1-liter bottle. Of that liter, 972 mL would be salt water. Only 28 mL would be fresh water… (Frank et al., 2000, p. B26).*[33]

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[32] The features in this glossary were identified in the current research; therefore, the glossary should not be considered an exhaustive list of all possible text features.

[33] Text examples marked with an asterisk were taken from the selections used in this study. The remaining examples were taken from other chapters in the same textbooks.

Classification:

To group or to divide things into groups according to their type (CID). In the example below, the author classifies different types of energy waves according to how they are perceived (e.g., light waves are seen; infrared waves are felt).

> Example:
> Energy from the sun travels in waves, as shown in the illustration below. There are several kinds of waves. Each kind carries a different amount of energy. We see some of the waves as visible light. We feel infrared waves as heat, and ultraviolet waves tan or burn the skin. The sun even produces radio waves, which we hear as radio or TV static. Some of the sun's energy, such as X rays, is harmful to life on Earth. But the atmosphere keeps most of the harmful energy from reaching Earth's surface (Frank et al., 2000, p. B117).

Comparison:

"Pointing out likenesses (comparison) and/or differences (contrast) among facts, people, events, concepts, and so on" (CAR, p. 254). In the first sample, comparison and contrast dominate the paragraph, which discusses the differential impact of having or not having atmosphere. Sometimes comparisons are implied, in that statements showing differences or similarities may be made without the explicit use of comparative grammar, as in example two below.

> Example 1:
> Without the greenhouse effect, Earth would be a much colder place–too cold to support most forms of life. Earth would be more like the Moon, which has no atmosphere. Without an atmosphere, there is no greenhouse effect. So the Moon's surface gets much colder than any place on Earth, as low as -173ºC (-279ºF). The atmosphere keeps Earth's average surface temperature at about 14ºC (57ºF) (Badders et al., 2000, p. E15).
>
> Example 2:
> A toy store finds that about 65% of its customers are less than 18 years old. At an electronics store next door, about 5/8 of the customers are under 18…. (Greenes et al., 2002, p. 541).*

Contradiction:

To show, state, or illustrate a direct opposition between things or an inconsistency (RHCD). In the example below, the author points out the contradiction between Thomas Jefferson's criticisms of slavery and the fact that he owned slaves.

> Example:
> Jefferson owned several slaves in his lifetime and lived in a slave-owning colony. Yet he often spoke out against slavery. "Nothing is more certainly written in the book of fate than that these people are to be free," he wrote (Banks et al., 2001, p. 314).*

Definition:

To say what the meaning of something, especially a word, is (CID). Some definitions are sentence level and some are extended definitions that may consist of single or multiple paragraphs. In the example below, a definition is provided for a key word in the paragraph.

> Example:
> An empire is a conquered land of many people and places governed by just one ruler. (Boehm et al., 2002, p. 101).

Description:

"Providing information about a topic, concept, event, object, person, idea, and so on (facts, characteristics, traits, features), usually qualifying the listing by criteria such as size or importance" (CAR, p. 254). The first example is a description of different types of clouds and includes an example of an embedded supporting feature–*explanation*–which tells why some clouds look darker than others. The second example provides factual information (e.g., description of what was sold) needed to solve a word problem.

> Example 1:
> Clouds look different depending on what they are made of. Water-droplet clouds tend to have sharp, well-defined edges. If the cloud is very thick, it may look gray, or even black. That's because sunlight is unable to pass through. Ice-crystal clouds tend to have fuzzy, less distinct edges. They also look whiter (Moyer et al., 2000, p. 122).

> Example 2:
> Orange juice and lemonade were sold during intermission. Three fifths of the sales were orange juice and 35% were lemonade. Which drink was less popular? (Greenes et al., 2002, p. 539).

Enumeration:

To name things separately, one by one (CID); often used for the purpose of providing examples or grouping items. Enumeration can occur within or across sentences and may involve a "listing" of two or more items. In example one, a list of materials used to decorate floats is provided. This is an example of enumeration embedded in a description, the dominant feature of the word problem. Example two shows an instance where only two items are enumerated.

Example 1:
The 111th annual Rose Parade in Pasadena, California, had 56 floats decorated entirely with flowers, seeds, vegetables, and even seaweed. After the parade the floats were lined up for exhibition. If the space needed for each float was 185 feet, how far did people walk to see all the floats? (Greenes et al., 2002, p. 114).

Example 2:
Chet had $20. He paid $8.95 for admission and $5.25 for lunch. Will he be able to buy a hat for $10? (Maletsky et al., 2001, p. 58).*

Exemplification:

To provide an example(s) for something that has been defined or discussed in a sentence or passage. Below, the author provides two examples of energy that are derived from fuel sources.

Example:
The sun is the source of most energy on Earth, but where does the sun's energy come from? On Earth, energy often comes from fuel. For example, burning gas or coal produces energy. But the sun's energy doesn't come from burning fuels. It comes from the fusing, or combining, of small particles to form larger ones (Frank et al., 2000, p. B116).

Explanation:

"Showing how facts, events, or concepts (effects) happen or come into being because of other facts, events, or concepts (causes)…Showing the development of a problem and solution(s) to the problem" (Vacca & Vacca, 1996, pp. 254-255). In the example below, the author explains how clouds form.

Example:
What has to happen for a cloud to form? The Explore Activity was a model of how clouds form. Clouds are made up of tiny water droplets or ice crystals. The air is filled with water vapor. When the air is cooled, the water vapor condenses. That is, the water molecules clump together around dust and other particles in the air. They form droplets of water (Moyer et al., 2000, p. 122).

Labeling:

To produce a term corresponding to a given definition (Butler et al., 2004). In the example below, the term "emperor" is produced after the definition is given.

Example:
An **empire** is a conquered land of many people and places governed by just one ruler. That ruler is called an **emperor** (Boehm et al., 2002, p. 101).

Paraphrase:

A strategy used to ensure the reader's understanding of a key phrase or word, whereby the key phrase or word is rephrased, often in a simpler way. In the example, the author provides a simpler word for "fusing."

Example:
It comes from the fusing, or combining, of small particles to form larger ones (Frank et al., 2000, p. B116).

Providing instruction or guidance:

Some texts refer to other lessons, provide suggestions, or give other types of guidance. In the first example, the text reminds students of a prior lesson. In the second example, students are given the unit of measure to use to solve the problem.

Example 1:
When water evaporates, remember, it leaves behind the material it contained (Moyer et al., 2001, p. 362).*

Example 2:
For the past 15 years, Tanya has jogged 10 miles per day. How many miles has she jogged altogether? Use 365 days per year (Maletsky et al., 2001, p. 158).*

Questions:

Questions are embedded in the texts for multiple purposes, including to stimulate critical thinking, to introduce new topics, to contextualize a topic in an everyday setting (see example one), and to review or call attention to prior lessons. In example two, the question acts as the topic sentence, introducing the reader to the content about to be discussed.

Example 1:
It's a cold day, and you and a friend are standing at a bus stop. You've been shopping, and you each have a package to hold. One package is quite heavy; the other is lighter but is larger and more bulky. Which package would you choose to hold? (Badders et al., 2000, p. C10).*

Example 2:
What did the Declaration say that made it so powerful? The purpose of the document was to explain to the world why the colonies had to separate from Great Britain…. (Banks et al., 2001, p. 316).*

Quotation:

Citations from primary sources may be used for multiple purposes, such as to explain a concept or to describe an event or place. In the first example, the quotation is a part of the content being taught. In the second example, the quote is used for the purpose of exemplification.

Example 1:
When Jefferson wrote, "We hold these truths to be self-evident," he meant that there are truths that should be clear to everyone (Banks et al., 2001, p. 316).*

Example 2:
Christianity inspired the slaves to compose spirituals, religious songs expressing strong desire for a better life. One included these lines: "There's a better day a-coming, Go sound the jubilee." The tradition of spirituals was one way black communities were strengthened (Armento et al., 1999, p. 410).*

Reference to text or visual:

Texts often refer students to different parts of a text in order to provide support for a lesson or concept. In the first example, the text refers students to a diagram that illustrates a written description. The second example refers students to an activity.

Example 1:
…The holds below the deck of the Mayflower were stuffed with barrels of salted beef and bread. The holds also contained pigs, chickens, and goats. The diagram above shows that the space below was very cramped for the more than 100 passengers on board…. (Banks et al., 2001, p. 187).*

Example 2:
…The activity that is on page E65 uses water in a bottle to model a tornado. The spinning water is shaped like a tornado. But unlike the water, air in a tornado spins upward (Badders et al., 2000, p. E72).*

Scenario:

To provide a scene for the purpose of exemplifying, aiding in conceptual understanding, or providing a context for problem solving. In the first example, a scenario is provided to introduce the topic of the lesson (e.g., matter). The second example is a classic mathematics word problem scenario.

> Example 1:
> It's a cold day, and you and a friend are standing at a bus stop. You've been shopping, and you each have a package to hold. One package is quite heavy; the other is lighter but is larger and more bulky. Which package would you choose to hold? (Badders et al., 2000, p. C10).*
>
> Example 2:
> Luisa and her brother are going to plant a garden that is 8 meters long and 6 meters wide. They each want to take care of a separate area. If they share equally, how much area will her brother get? (Willoughby, Bereiter, Hilton & Rubinstein, 2003, p. 195).*

Sequencing:

"Putting facts, events, or concepts into a sequence. The author traces the development of a topic or gives the steps in the process. Time reference may be explicit or implicit, but a sequence is evident in the pattern" (CAR, p. 254). The first example is excerpted from a passage about migration in America. The second example is an excerpt from a passage about matter describing the steps needed to measure something.

> Example 1:
> In 1836 two missionary couples set out on the Oregon Trail. Marcus and Narcissa Whitman and Henry and Eliza Spalding hoped to teach the Cayuse people in the Oregon Territory about Christianity. After traveling about six months, the Whitmans set up their mission near the Columbia River. The mission also served as a resting place for travelers….
>
> Early in 1847 another group of religious followers headed west. More than….
>
> Finally, in July 1847, the first group of Mormons reached a large lake now known as the Great Salt Lake…By 1850 there were about 5,000 Mormons living in the town (Banks et al., 2001, p. 429).
>
> Example 2:
> Suppose you want to know how much water or some other liquid is in a container of some kind. First you pour the liquid from the container into a graduate. Then you measure the level of the liquid against the scale marked on the side of the graduate (Badders et al., 2000, p. C12).*

Simile:

"A figure of speech in which two unlike things are explicitly compared, as in 'she is like a rose'" (RHCD, p. 1226). In the example below, the concept of a how a tornado gains its speed is compared to a figure skater.

Example:
Like a spinning skater who pulls her arms in close to her sides, the spinning tornado gets faster and faster (Moyer et al., 2000, p. 164).*

Summary:

To express the most important facts or ideas about something or someone in a concise form (CID). The example below summarizes the critical facts students must understand in a lesson about plant reproduction.

Example:
Most flowers have both male and female reproductive parts. Pollen, which has sperm cells, is produced by stamens. The pistil has the eggs. Pollen is transferred from the stamens to the pistil. After fertilization, eggs develop into seeds. Many flowers attract animals that carry pollen to the pistil. In some plants, pollination depends on the wind. (Frank et al., 2000, p. A119).*

Mathematics Task Features[34]

Justification:

To provide evidence or give a reason or explanation for something based on experience, knowledge, or facts (adapted from CID). In the example below, students are asked to provide examples that support their answers.

Example:
How many equivalent fractions can be written for any given fraction? Give examples to support your thinking (Greenes et al., 2002, p. 319).*

Write problem or question:

Students are asked to write a problem or to generate a problem question when given certain specifications or guidelines. The first example requires students to generate a word problem and the second only asks for the problem question.

Example 1:
Write a problem that has too little information to be solved. Then write one that includes information that is not needed to solve the problem (Maletsky et al., 2001, p. 551).*

[34] In this subsection, we list features in the task or problem question of mathematics word problems that require language production and that only occur in mathematics selections.

Example 2:
What's the question? Eileen bought 2 gallons of milk at $3.02 per gallon and one loaf of bread at $.99. The answer is $7.03 (Maletsky et al., 2001, p. 173).*

APPENDIX L

Synthesis of Grammatical Features of Language Functions in Textbooks and Printed Materials[1]

[1]References Table 11 from Butler et al. (2004).

Table L1

Synthesis of Grammatical Features of Language Functions in Textbooks and Printed Materials

Grade cluster	3-5	3-5	3-5	6-8	Multiple	6-8	9-12
Content area	Math, Sc	Sc	SS	SS	Math	Hist	Geo, Hist, Sc
Research study	Butler et al. (2004)	Bailey et al. (2004)	Butler et al. (1999)	Butler et al. (1999)	Dale & Cuevas (1982)	Short (1993)	Coelho (1982)
Functions							
Comparison/Contrast							
Adverbial comparatives	•	•	•		•		•
Comparative adj forms	•	•			•		•
Equative comparative forms					•		
Imperative verb forms	•						
Logical connectors:	• (c)	• (b)		• (a,b,c,d)			• (a,b,d)
a) Conflict or contrast							
b) Exemplification							
c) Replacement							
d) Similarity							
Description							
Imperative verb forms	•	•					
Logical connectors:	• (a)	• (b)		• (a,b)	• (b,c)		• (b,d)
a) Effect/result							
b) Exemplification							
c) Sequential							
d) Similarity							
Modals			•	•			
Nominal structures	•				•		•
Passive voice	•				•		•
Phrasal verbs		•		•			
Predicate adj structures	•						
Prepositions		•			•		•
Simple past				•			
Simple present	•	•	•				
Subordinate clauses (e.g., relative clauses)		•		•	•		
Temporal phrases			•			•	
Explanation							
Imperative verb forms	•						
Logical connectors:			• (a,b,c)	• (a,b)	• (a,b,c)	• (a)	• (a,b,c)
a) Cause/reason							
b) Condition							
c) Effect/result							
Modals	•	•					

Verb *cause* w/ infinitive	•	•

Note. Sc = Science; SS = Social Science; Hist = History; Geo = Geography; Adj = Adjective.

APPENDIX M

General Procedures For Text Selection: Stage 1

Materials needed:

1. General Guidelines for Stage 1
2. *Subject Area Guidelines with sample texts*
3. *Text Selection Checklist Form*
4. *Grade Level Standards & Indicators [CA standards]*

Steps:

1. Review the *General Guidelines for Stage 1*, the *Subject Area Guidelines* for the subject area you will be selecting texts from, and the *Text Selection Checklist Form*.
2. Review the first content standard and the performance indicators for that standard.
3. Select one performance indicator for the standard.
4. Using the *Subject Area Guidelines* and the selected indicator as guides, identify one text.
5. After identifying the text selection, complete the *Text Selection Checklist Form* to verify that it fits the criteria for selection.
6. If the text is judged appropriate, complete the following steps:
   (a) Photocopy the text selection;
   (b) Write the name of the textbook and author on the top right hand corner of the photocopy and be sure the page numbers are clear;
   (c) Write the content standard number and performance indicator number on the left hand corner of the photocopy.
7. Attach the completed checklist to the front of the text selection and continue selecting texts using the same procedures above.