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Language Correlates of Disciplinary Literacy

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Disciplinary literacy is defined here as the ability to engage in social, semiotic, and cognitive practices consistent with those of content experts. Characterizing literacy development as a process of braiding 3 language strands of everyday language, abstract language, and metaphoric language, this article describes the lexical and grammatical patterns typical of disciplinary texts in the subjects of language arts, science, mathematics, and history, showing how language is used in discipline-specific ways to present knowledge, construe value, and create specialized texts. It argues that literacy instruction in academic disciplines should move beyond the time-honored focus on basic skills (e.g., vocabulary, fluency), general cognitive strategies (e.g., predicting, inferencing), and generic learning strategies (e.g., highlighting, note taking) to embrace an emphasis on discipline-specific practices that promote simultaneous engagement with disciplinary language and disciplinary content. **Key words:** *adolescent literacy*, *disciplinary literacy*, *functional linguistics*, *linguistic variation*, *literacy development*

RECENT REPORTS (Biancarosa & Snow, 2006; Graham & Perin, 2007) suggest that more than 70% of students in grades 4–12 are experiencing difficulties when reading and writing texts in academic content areas. Concerns over adolescents' lack of literacy skills and academic underperformance have revitalized discussion about effective ways to promote academic literacy among adolescents (Draper, Broomhead, Jensen, Nokes, & Siebert, 2010; Fang & Schleppegrell, 2008; Heller & Greenleaf, 2007; Jetton & Shanahan, 2012; Langer, 2011; Lee & Spratley, 2010; McConachie & Petrosky, 2010; Moje, 2008; Shanahan & Shanahan, 2008). One prominent theme in this discussion is that literacy instruction in middle and high schools should shift its focus from content area literacy to disciplinary literacy. Content area literacy has been defined as the ability to use reading and writing effectively as tools for thinking about and learning from texts across different school subjects (Bean, Readence, & Baldwin, 2008; Vacca, Vacca, & Mraz, 2011). It is rooted in the beliefs that the cognitive requirements of reading and learning from texts are essentially the same regardless of content areas and that the primary difference among school subjects is in their content (Shanahan & Shanahan, 2012). As such, content area literacy emphasizes the acquisition of basic reading skills (e.g., decoding, vocabulary, fluency), cognitive text processing strategies (e.g., predicting, summarizing, inferencing, monitoring, questioning, visualizing), and generic learning strategies (e.g., highlighting, note taking, concept mapping). These skills and strategies are believed to aid students in extracting information from any content area text and hence the learning and retention of content in school subjects.

Disciplinary literacy, on the contrary, refers to the ability to engage in social, semiotic, and cognitive practices consistent with those of content experts. It is grounded in the beliefs that reading and writing are integral to

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disciplinary practices and that disciplines differ not only in content but also in the ways this content is produced, communicated, and critiqued. From this perspective, literacy is no longer just a set of strategies or tools to be imported into the disciplines to improve reading and writing of texts across content areas; it is an essential part of disciplinary enculturation and socialization (Moje, 2008). Being literate in a discipline means both deep knowledge of disciplinary content and keen understanding of disciplinary ways of making meaning. This suggests that literacy at the secondary level "must be anchored in the specifics of individual disciplines" (McConachie & Petrosky, 2010, p. 15) and its development involves simultaneous engagement with disciplinary content (e.g., core concepts, big ideas, key relationships) and disciplinary habits of mind (e.g., reading–writing, viewing–representing, listening–speaking, thinking–reasoning, and problem-solving practices consistent with those of content experts).

This shift toward a discipline-based approach to literacy instruction reflects growing recognition among literacy scholars and content experts that literacy practices vary across disciplines and that these practices are best learned and taught within each discipline. Disciplines differ in how they generate, communicate, evaluate, and renovate knowledge (see, e.g., Wineburg, 2001; Yore, Hand, & Florence, 2004); and these differences are manifested in how content experts use language in their social–cognitive practices (Fang & Schleppegrell, 2008). This article illuminates the different ways language is used by content experts to present information, structure text, and embed values in the core academic disciplines of language arts, science, mathematics, and history. It also discusses the implications of this linguistic variation for the development of disciplinary literacy in the context of secondary schooling.

LANGUAGE, KNOWLEDGE, AND LITERACY: A FUNCTIONAL VIEW

This article adopts a functional linguistics framework (Halliday, 1978, 2004) that sees language as both a theory of human experience and a creative resource for making meaning. Language enables experience to be transformed into meaning. It is through this transformation that people come to understand their experiential world, and the outcome of this transformation is what is called *knowledge*. As Halliday (2004) notes, "Understanding, and knowing, are semiotic processes—processes of the development of meaning in the brain of every individual; and the powerhouse for such processes is the grammar" (p. 11). In other words, "knowledge is prototypically made of language" (Halliday, 2004, p. 25).

According to Halliday (2004), the experiential world, the physical environment in which people live their lives, is made up of a random flux of happening and, as such, it can be perceived in many different ways. Language enables people to construct a semiotic universe that is analogous to human experience, and in so doing gives order, regularity, and proportionality to the highly complex interactions between human beings and their environment. Specifically, through its lexicogrammar (e.g., nouns, verbs, adjectives), language imposes categories and relationships on people's perceptual world and construes human experience into "a multidimensional semantic space" (Halliday, 2004, p. 11). This lexicogrammar is a "highly elastic" and "optimally functional" system (Halliday, 2004, p. 11), offering a wide array of choices that allow language users to make different kinds of meaning according to their individual needs and purposes.

From the functional linguistics perspective, then, literacy is a language-based semiosis and thus can be treated as part of language development (Halliday, 2007; Hasan, 1996). According to Halliday (2004), there are three critical moments of language development in children. The first moment occurs during infancy, at the ages of 1 to 2 years, when children move from infant protolanguage to mother tongue. During this process, children start to construe classes, developing the ability to generalize from proper names to common names. These common names refer to

phenomena that are directly accessible to the senses, making possible commonsense theories of knowledge.

The second critical moment occurs between the ages of 4 and 6 years, when children move from everyday spoken grammar to the grammar of literacy (i.e., reading/writing). During this process, children reconstrue experience in more abstract ways, demonstrating a capacity to handle entities that have no perceptual correlates. This capacity for abstraction signals the onset of literacy, suggesting that children in this stage can process abstract signs such as written language and are ready to move into educational forms of knowledge.

The third critical moment of language development takes place around puberty, at the ages of 9 to 13 years, when children move from the grammar of written language to the language of content areas. During this process, children develop the ability to use grammatical metaphors, that is, to replace one grammatical class with another. They learn to reconstrue experience in a more theoretical mode, one that is grammatically incongruent with the commonsense construal of the world. For example, in the congruent (i.e., everyday) construal of experience, happenings are realized grammatically as verbs, qualities as adjectives, things as nouns, and logical relations as conjunctions; but in noncongruent construals, qualities (e.g., *diverse*) are realized as nouns (e.g., *diversity*); happenings (e.g., *to increase intensity*) as nouns (e.g., *the increase in intensity*) or adjectives (e.g., the *increasing* intensity); and logical relations (e.g., *because*) as nouns (e.g., *the reason*), verbs (e.g., *trigger*), or prepositions (e.g., *with, at*). This capacity for metaphoric construal of experience suggests that children are ready to engage with technical knowledge of academic disciplines.

These three critical moments of language development have been characterized by Halliday (2004) as "three successive waves of energy," with each wave enlarging children's meaning potential and at the same time taking them one step away from their ordinary everyday experience. As children move from one wave to the next, they do not let go of their previously learned grammar. Rather, the three kinds of grammar coalesce and are "enshrined in the grammatical construction of the text" (p. 46). From this perspective, literacy development can be viewed as the braiding of these three strands of language (Figure 1). During the preliteracy stage (ages birth through 4), children learn the mother tongue (i.e., everyday spoken language) for construing commonsense knowledge. This language development takes place primarily at home in interaction with family members. During the basic, or functional, literacy stage (ages 4 through 9), children learn to control written language and the abstract mode of meaning that enable them to participate functionally in a print-literate culture. This language development takes place mainly from preschool through third grade, with family and peer groups playing an equally important role. During the advanced, or disciplinary, literacy stage (ages 9 through 18), children begin to cope with discourse that is grounded in grammatical metaphor. This type of discourse is typically found in the academic subjects of secondary and tertiary schooling, where specialized, technical knowledge becomes the focus of study. Disciplinary literacy builds on, rather than excludes, the language skills (e.g., generalization, abstraction) and knowledge (commonsense, educational) that have been developed during the preliteracy and basic literacy stages and are continuing to develop during the disciplinary literacy stage.

Not only does language become progressively more abstract and metaphoric as the knowledge children have to deal with becomes more advanced and specialized, but it also varies from one academic discipline to another. As Macken-Horarik, Love, and Unsworth (2011) noted, "Language resources don't just become more complex and abstract as students progress through the years; they pattern and copattern at all levels of choice in distinct ways" (p. 17). Although it is widely recognized that different disciplines have their own lingos, it is not always apparent that the grammar is also different across disciplines. For example,

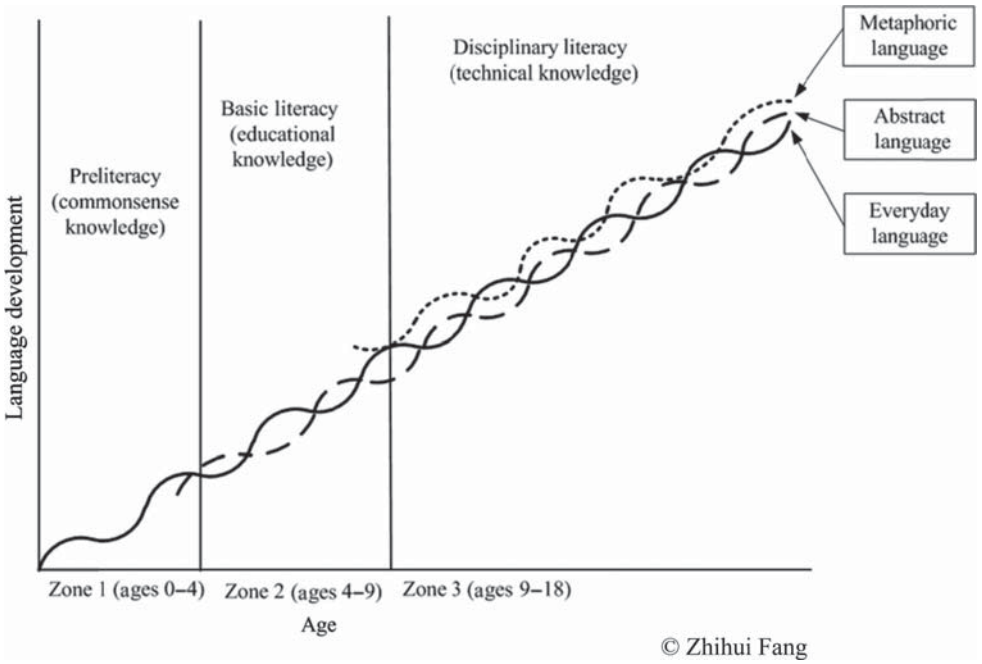

Figure 1. Literacy development represented as the braiding of three language strands. (Copyright, Zhihui Fang, 2012, shared by permission of author.)

scientists construe theoretical explanations about the natural world through dense nominal syntax with technical and abstract vocabulary. Mathematicians prove axioms, theorems, lemmas, corollaries, and relationships by drawing simultaneously on the resources of natural language, symbolic language, and visual display. Poets create multilayered language play with graphology, phonology, words, syntax, and semantics in their texts. Historians use abstract language to enable the shift from chronological retelling of past events to a biased interpretation of these events. These linguistic differences, which are illuminated further in the next section, are a reflection of the fundamental differences in the ways content experts conduct their social, semiotic, and cognitive work.

VARIATION IN LANGUAGE USE ACROSS ACADEMIC DISCIPLINES

According to Hasan (1996), academic disciplines are largely "a constellation of certain types of discourse" and "what counts as knowing a discipline is the ability to participate successfully in the discourses of that discipline" (p. 398). Disciplinary discourses are constructed in distinct language patterns that enable content experts to conduct their work. Some of these language patterns are identified and discussed below. Recognizing these discipline-specific ways of using language can help students develop a sense of how a discipline organizes knowledge and construes value through language, enabling them to better read, write, evaluate, and renovate texts in the disciplines (Fang, 2012).

Language arts

English language arts teachers have as their primary goal the development of students' capacity to read, respond to, evaluate, and create texts (Christie & Derewianka, 2008). Although texts of diverse types and modalities are used in the language arts curriculum, literature invariably remains the focus of study. As works of creative imagination,

literature encompasses many different genres, including poetry, drama, adventures, biographies, science fictions, folktales, comedies, tragedies, mythology, fantasies, and short stories. Because literature relates closely to the concerns, emotions, behaviors, imaginations, dreams, and other aspects of ordinary human life, it draws on the same sort of language people use in their everyday social interaction. As Lukin (2004) pointed out, what makes literature, such as poetry, a piece of artwork is not that it draws on some particular style of language, but that it exploits the lexicogrammatical resources of everyday language. In other words, it is the creative way everyday language is manipulated for aesthetic ends that gives a piece of literature its special character.

Text 1 (below) is an extract from *Pink* (Wilkinson, 2009), which is an entertaining and thought-provoking young adult novel featuring Ava Simpson, an adolescent who struggles with her lesbian identity as she tries to fit in with the teen culture.

Text 1

I waited until he'd turned a corner, and then I reached for Chloe's hand. Despite the shock, it was good to see her. We hadn't hung out all week, and I'd missed her. I wondered for an instant whether I was happier to see Chloe than I was sad to see Ethan leave, but pushed it to the back of my mind.

"What a nice surprise," I said. "Seeing you."

Chloe pulled away, "What's going on?" she said, her voice quiet and small.

I'd thought she was going to yell at me. I'd thought she'd make a scene. But this quiet, pale, trembling Chloe was someone I'd never seen before.

"I can explain," I told her.

Chloe stared at the tram tracks, her lips pressed close together. (p. 172)

Narrated in the first person, this extract describes Ava's unexpected encounter with her lesbian girlfriend Chloe in the subway station while Ava is out with her new boyfriend Ethan. The text uses short clauses with simple noun phrases that refer to specific, concrete participants (*I, we, Chloe, it, Ethan, her*); different types of verbs to represent what the participants did, thought, felt, and said (*waited, reached, pulled; wondered, thought, stared; was; said, told, yell*); and simple prepositional phrases and nonfinite clauses to indicate the location, cause, time, and manner of the activities (*to the back of my mind, at the tram tracks; for Chloe's hand; for an instance, all week, before; her voice quiet and small, her lips pressed close together*). Many of these clauses are linked together into sentences through coordination (*and, and then*) or subordination (*until, despite, whether*) or both. The characters' thoughts, feelings, and dialogues (*wondered, thought, was good, was sad, had missed, said, told*) are juxtaposed with dynamic actions (*pulled away, reached for, turned*) to create a lively scene that engages the reader.

The grammatical patterns identified here bear great resemblance to those found in everyday spoken language, where language often accompanies some ongoing activity expressing who does what, what happens next, and so on. Such use of language captures the dynamism and fluidity of speech, enabling the author to create long stretches of semantic movement and at the same time maintain a coherent discourse that is loosely strung together (Halliday, 2007). As such, these grammatical patterns typically do not present much comprehension challenge for students who have already developed reading fluency in the elementary school. What students, particularly those experiencing language and learning difficulties, may find challenging is to interpret the figurative language (e.g., metaphor, simile, symbolism) and peculiar vocabulary (e.g., archaic words) that are sometimes embedded in the literary texts they read.

Science

Science is a discipline that aims at increasing people's understanding of the natural world and its phenomena. It involves "[s]ystematic investigation of meaningful questions about natural phenomena and the development of evidence-based

explanations" (Krajcik & Sutherland, 2010, p. 456). The social practices of scientists are catalogued in a range of genres that students are expected to be able to read and write. The predominant genre of science is research report, which typically combines in different ways the five basic science genres of procedural recount, procedure, report, explanation, and exposition (Fang, 2010). The structure and grammar of research report are necessarily different from those of literature, as they provide the semiotic means through which scientists do, explain, theorize, organize, and challenge science. Unlike the more dynamic language of Text 1, the language of science tends to be more static and crystalline. As Halliday (2004) noted,

> Whereas the grammar of daily life tolerates—or rather, celebrates—being indeterminate, varying and flowing, the elaborated, nominalized grammar of science imposes determinacy, constancy and stasis. It construes a world that is made ultimately of things. (p. 129)

The static nature of the language of science is exemplified in Text 2. The extract comes from an article by Nielsen and Graveley (2010), which was published in *Nature*, one of the world's leading journals in the field of science. The research report is about alternative splicing, the process by which multiple different functional messenger RNAs and proteins can be synthesized from a single gene.

Text 2

> A final example of the importance of kinetics in alternative splicing comes from studies of the *D. metlanogaster gene Dscam* (Fig. 3c), which (as indicated earlier) encodes more than 38,000 mRNA isoforms. This remarkable diversity is mainly generated by mutually exclusive splicing of pre-mRNA sequence corresponding to four large, independently controlled clusters of alternative exons[6,49]. The mutually exclusive splicing of one of these exonic sequence clusters, that corresponding to exon 6, is mediated by competing RNA secondary structures that form between a single docking site and one of the selector sequences located upstream of each of the 48 alternative exonic sequences[50,51] (Fig. 3c) in the mRNA. (p. 459)

This text deals with a highly specialized topic, one that is far removed from students' everyday life experience. To construct this technical knowledge, the text uses language patterns that are distinct from those used in Text 1. One obvious feature of Text 2 is the use of specialized vocabulary and acronyms (e.g., *kinetics, D. metlanogaster gene Dscam*, *exons, mRNA, isoforms*), as well as vernacular terms that assume technical meanings (e.g., *splicing, cluster, sequence, docking site, upstream*). In addition to these technical terms, the text uses noun phrases extensively, many of them long, such as the following:

- A final example of the importance of kinetics in alternative splicing
- studies of the *D. metlanogaster gene Dscam*
- more than 38,000 mRNA isoforms
- This remarkable diversity
- The mutually exclusive splicing of pre-mRNA sequence corresponding to four large, independently controlled clusters of alternative exons
- The mutually exclusive splicing of one of these exonic sequence clusters
- competing RNA secondary structures that form between a single docking site and one of the selector sequences located upstream of each of the 48 alternative exonic sequences

These noun phrases contain a large quantity of information that in the more commonsense language of everyday life would require several sentences to express. For example, the last noun phrase can be unpacked this way into structures that are more congruent with the commonsense grammar: *RNA secondary structures compete against each other. They form between a single docking site and one of the selector sequences. The selector sequences are located upstream of each of the 48 alternative exonic sequences*. It is through multiple layers of grammatical modification and embedding that discrete pieces of information are integrated and condensed into the nominal structure. The resulting noun phrases are abstract or metaphoric entities that then participate as new theoretical objects in the

syntactic relations of coexistence, revelation, or causation. At the same time, they provide linkages across sentences, contributing to information flow in the text. For example, *this remarkable diversity* in the beginning of the second sentence is a metaphoric entity that summarizes what has been discussed in the first sentence, *the D. metlanogaster gene Dscam encodes more than 38,000 mRNA isoforms*, and that serves as the point of departure for continuing discussion of the topic. Similarly, *the mutually exclusive splicing of one of these exonic sequence clusters* in the third sentence synthesizes the ideas discussed in the second sentence into a theoretical object, which is then further discussed. The dual role of nouns as a grammatical resource for construing both technicality and rationality in scientific discourse is captured in the following quote from Halliday (2004):

> Scientific discourse rests on combining theoretical technicality with reasoned argument; and each of these relies on the same metaphorical resource within the grammar. Semantically, each relies on the grammar's power of condensing extended meanings in a highly structured, nominalized form. In the latter, it is a textual condensation, in which stretches of preceding matter are condensed instantially, to serve as elements . . . in the ongoing construal of information. (p. 127)

These grammatical features appear not just in the professional discourse of practicing scientists, they are also evident in school science texts, which can be considered technical science discourse recontextualized for educational purposes (Fang, 2006). The following extract (Text 3) from a high school biology textbook, for example, includes both long noun phrases (underlined) and technical terms (in italics). Some nominalizations, such as *this uncontrolled dividing of cells* and *this loss of control*, distill previously presented information and serve as the point of departure—that is, the grammatical subject—for continuing discussion on the topic. Other nominalizations—such as *interaction, failure, overproduction, production, growth,* and *changes*—enable condensation of information into 'things" that then participate as virtual entities in the processes of cell division.

Text 3

> The *cell* cycle is controlled by *proteins* called *cyclins* and a set of *enzymes* that attach to the *cyclin* and become activated. The interaction of these *molecules*, based on conditions both in the *cell*'s *environment* and inside the *cell*, controls the *cell* cycle. Occasionally, *cells* lose control of the *cell* cycle. This uncontrolled dividing of *cells* can result from the failure to produce certain *enzymes*, the over production of *enzymes*, or the production of other *enzymes* at the wrong time. Cancer is a malignant growth resulting from uncontrolled *cell* division. This loss of control may be caused by *environmental* factors or by changes in *enzyme* production. (Biggs et al., 2006, p. 211 emphasis and underlining added)

As Texts 2 and 3 show, scientific discourse privileges nouns, as they are a key grammatical resource for compacting information, creating technical objects, developing logical reasoning, facilitating discursive flow, and achieving precision and concision (Halliday, 2004; Halliday & Martin, 1993). At the same time, however, they also result in texts that are simultaneously technical, dense, and abstract because every nominal compacting creates progressively higher order abstraction and technicality that bury agency and concrete referential information, making them increasingly difficult to comprehend and critique. This way of presenting information and structuring text is different from Text 1, where nouns are generally short and nontechnical and clauses are typically strung together through coordinating or subordinating relations or both.

Another feature of Text 2 is the incorporation of figures, which are referenced but not reproduced above. Science texts often integrate visual (e.g., tables, diagrams, charts), graphical (e.g., maps, drawings, photographs), and mathematical (e.g., symbols, equations, algebraic derivations) resources with verbal resources (i.e., words in sentences and paragraphs). This codeployment of multisemiotic resources is necessary because

verbal (i.e., linguistic) resources are no longer adequate for making meaning in modern Western science. According to Lemke (2002), although linguistic resources are a powerful tool for classification and conceptualization in science, they are less effective in describing variables such as shape, temperature, velocity, angle, color, voltage, concentration, and mass, for which visual and spatial–motor representations are better suited. The figures referenced in Text 2 (not shown here) facilitate a more accurate, complete, and efficient presentation of information.

Mathematics

Mathematics, too, has evolved a language that is functional for construing mathematical knowledge and reasoning. However, like science, mathematics texts are "semiotic *hybrids*" (Lemke, 1998, 2003); they draw on not only linguistic resources (i.e., natural language) but also symbolic and visual resources in the construction of mathematical meanings (O'Halloran, 2005). Mathematical symbols, such as $\sum, f(\chi), \pi, \eta, =$, and β, are used to represent concepts, axioms, lemmas, corollaries, theorems, operations, and relationships that are sometimes awkward to express in language. For example, the equation $d = (at^2)/2$ is used to calculate the distance that an object travels in time t at acceleration rate a. The complete pattern of the relationship between distance (d) and time (t) is described here with both concision and precision, a feat difficult to accomplish with natural language alone. Visual displays such as graphs, charts, and diagrams are also important in mathematics meaning making because they enable mathematicians to represent the linguistically and symbolically encoded information in ways that are tangible to the human perceptual sense. For example, the relationship between time and distance encoded in $d = (at^2)/2$ can be graphically represented in an upward curve (Figure 2), which gives the reader instant insights into the nature of this relationship. O'Halloran (2000) summarized the functions of the three semiotic resources in mathematics this way:

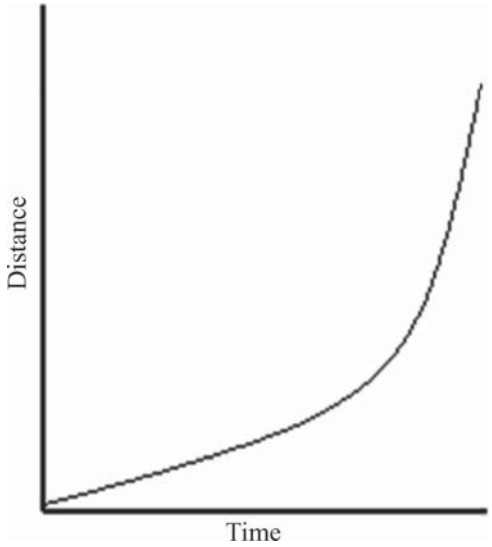

Figure 2. Distance–time graph illustrating the relationships of d = distance, a = acceleration rate, and t = time encoded in the equation, $d = (at^2)/2$.

> [T]he mathematical symbolism contains a complete description of the pattern of the relationship between entities, the visual display connects our physiological perceptions to this reality, and the linguistic discourse functions to provide contextual information for the situation described symbolically and visually. (p. 363)

Mathematics textbooks in secondary schools are typically made up of chunks of text labeled *hypothesis, theorem, proof, example, exercise, review,* and so on. Two such chunks are presented in the following text. Text 4 is the Pythagorean theorem from a middle school algebra textbook (Larson, Boswell, Kanold, & Stiff, 2001). Text 5 is a word problem from a high school geometry textbook (Jurgensen, Brown, & Jurgensen, 2004).

Text 4

> If a triangle is a right angle, then the sum of the squares of the lengths of the legs a and b equals the square of the length of the hypotenuse c. (Larson et al., 2001, p. 738)

Text 5

> Find the height and the volume of a regular hexagonal pyramid with lateral edges 10 ft and base edges 6 ft. (Jurgensen et al., 2004, p. 486)

Both texts contain technical and semitechnical vocabulary that can present challenges to reading, understanding, and problem solving. Some of these technical terms—such as *triangle*, *hypotenuse*, and *hexagonal*—are uniquely mathematical. They are essential to mathematics because they encapsulate many of the key concepts of the discipline. Another type of technical vocabulary in these extracts includes everyday words that take on specialized meanings. These include *right, legs, base*, *volume*, *edge*, *feet*, *regular*, and *find*. They can be just as problematic to students. For example, the word *edge* usually refers to the thin, sharpened side of the blade of a cutting instrument, but in mathematics it means the line of intersection of two surfaces of a solid.

Semitechnical terms in the two sample texts include *sum, square, length,* and *height*. These are nominalizations that derive from verbs or adjectives. Nominalization is an important grammatical resource in mathematical meaning making. It helps create abstract "things," or metaphoric entities, that can be qualified, reified as mathematical concepts, or participate in mathematical reasoning (Veel, 1999). For example, when mathematical operations such as "to sum" and "to square" are nominalized, they turn into virtual objects (*sum* and *square*) that encapsulate processes. These objects then can be qualified by adding pre- and postmodifiers (shown with underlining) and then entered into relations with each other and with other concepts through the use of prepositions (*of*) and verbs (*equals*): *the sum of the squares of the lengths of the legs a and b equals the square of the length of the hypotenuse c*. Similarly, the word *height*, which comes from its adjectival form *high*, becomes a key concept in the discussion of volume. As a noun, it can be further qualified by adding, for example, a prepositional phrase, as in *the height of a regular hexagonal pyramid*.

As the previous examples show, technical vocabulary and semitechnical terms do not occur in isolation in mathematics texts; they enter into relations with each other and with other grammatical elements in the text. An outcome of this interaction is long noun phrases that contain a large quantity of information. These noun phrases need to be deconstructed in order for students to fully understand the mathematical processes and reasoning encoded in them. For example, *the sum of the squares of the lengths of the legs a and b* in Text 4 is a long noun phrase that construes three mathematical operations. These operations include (a) squaring the length of the leg *a*, (b) squaring the length of the leg *b*, and (c) adding the results of (a) and (b). Similarly, Text 5 contains a long noun phrase, *the height and the volume of a regular hexagonal pyramid with lateral edges 10 ft and base edges 6 ft*, which is construed here as a mystery virtual object to be found (or rather, solved). This long noun phrase can be unpacked into grammatical structures that correspond to the commonsense reality of everyday world: *There is a regular hexagonal pyramid. The lateral edges of the pyramid measure 10 feet. The base edges of the pyramid measure 6 feet. What are the height and volume of this pyramid?* Without an understanding how these data are packed in the long noun phrase, students are likely to struggle with comprehending, not to mention solving, the problem. Thus, as Lager (2004) and Moschkovich (2010) have suggested, language remains a key issue in mathematics learning, particularly for those learning English as a second language or experiencing language-learning disorders.

To truly understand and apply the Pythagorean theorem presented in Text 4, students must, in addition, be able to translate the language of the text into mathematical symbolism, $a^2 + b^2 = c^2$, recognizing the types of mathematical operations and reasoning (e.g., addition, squaring) buried in these symbols. This translation, in turn, depends on successful construction of a visual display, such as Figure 3, that enables students to visualize the abstract information presented in words and symbols. Likewise, solving the problem in Text 5 requires that students understand the mathematical formula, expressed in symbols

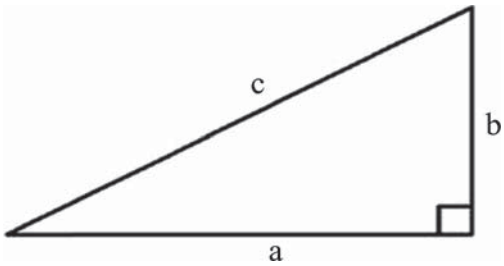

Figure 3. Right triangle diagram illustrating the Pythagorean theorem.

as $V = anbh/6$ (where V = volume, a = apothem length, n = number of sides on the base, b = length of the side on the base, and h = height of the prism), in the context of a visual display (Figure 4).

History

The job of the historian is to create a narrative of the past to better understand the present. The creation of such a narrative is "a process of constructing, reconstructing, and interpreting past events, ideas, and institutions from surviving or inferential evidence" (Ravi, 2010, p. 36). Perhaps more than any other discipline, history is a literate practice that depends on texts of both primary and secondary sources because historical events happened once and disappeared, leaving behind only historical residues in the form of texts (e.g., documents, records, artworks) for the historian to read, analyze, and interpret (Bain, 2008). Typical historical discourse juxtaposes recording, explaining, and arguing, with some texts relying heavily on chronological recounting of past events and others foregrounding explanation or argument (Coffin, 2006; Martin, 2002; Schleppegrell, 2004). In recording, the historian retells past events as they unfolded naturally through real time. In explaining, the historian explains the causes, consequences, and significance of historical events. In arguing, the historian proposes a particular interpretation on past events and defends it with a series of argument and supporting evidence. This movement among retelling, explaining, and arguing predicts a need for using language resources in ways different from other disciplines.

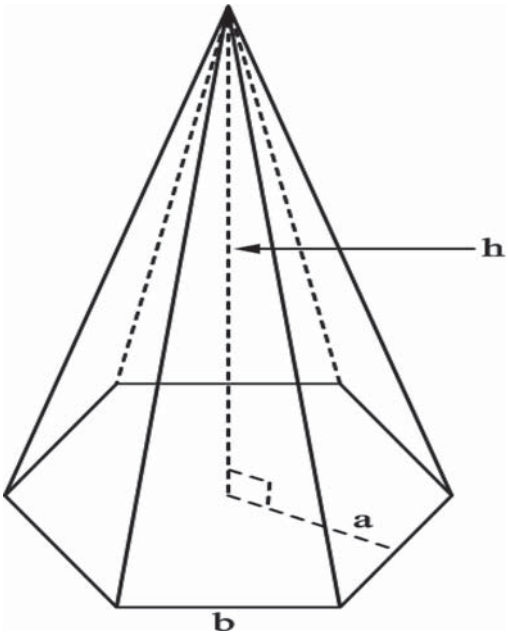

Figure 4. Regular hexagonal prism illustrating the information presented in the mathematical formula for calculating volume.

Text 6 is an extract from Crowe's (2003) *Getting Away with Murder*, an award-winning social studies trade book that chronicles the historically significant trial of two white men who abducted and killed a black boy named Emmett Till in the state of Mississippi. It follows an account of the people and events connected to the murder of Emmett Till.

Text 6

The kidnapping and murder of Emmett Till and the trial of his killers became one of the biggest news items of 1955. The viewing of his disfigured corpse at Rainer Funeral Home and his funeral at the Roberts Temple of the Church of God in Christ in Chicago attracted more than ten thousand mourners. The grisly open-casket photo of Emmett that appeared in *Jet* magazine horrified and angered hundreds of thousands more. The National Association for the Advancement of Colored People (NAACP), other civil rights organizations, and political leaders expressed outrage at the cold-blooded murder of this boy from Chicago. In an interview, Roy Wilkins, Executive Secretary of

the NAACP, labeled the crime a racist act, saying, "It would appear that the state of Mississippi has decided to maintain white supremacy by murdering children." Newspapers across the country, especially those in the Northern states, condemned the killing and the racist attitudes that led to it.

The protests and condemnations from civil rights leaders and Northerners poked an already raw nerve in the South. The white leaders in Southern states like Mississippi that enforced Jim Crow laws, regulations that segregated Blacks from whites, were still stinging from the 1954 Supreme Court decision *Brown v. Board of Education of Topeka*, which declared that racially segregated schools were unconstitutional. In May of 1955, the Supreme Court pushed the issue even further when it ordered that integration of schools must proceed "with all deliberate speed." The two rulings alarmed Southern leaders who feared that the federal government and Northern agitators planned to destroy the Southern way of life. (pp. 18–20)

This extract analyzes and interprets the kidnapping and murder events recounted in the preceding three pages of the book. It is dense and abstract. The density is achieved through the use of long noun phrases such as *one of the biggest news items of 1955; the grisly open-casket photo of Emmett that appeared in Jet magazine*; *the white leaders in Southern states like Mississippi that enforced Jim Crow laws*; and *Southern leaders who feared that the federal government and Northern agitators planned to destroy the Southern way of life*. But what truly distinguishes Text 6 from other texts is its use of abstractions. The text is populated with "things," realized grammatically as nouns or noun phrases that are patterned differently from the "things" in Texts 1–5. According to Martin (1997), there are three types of grammatical "things": concrete, abstract, and metaphoric. Concrete "things" are those that have perceptual correlates in the material world (e.g., *rock, Chicago*). Abstract "things" refer to items that have no concrete referents in the material world and often have to be defined linguistically to enable full understanding. They include technical abstractions (e.g., *gene, inflation*), institutional abstractions (e.g., *policy, government*), semiotic abstractions (e.g., *idea, concept*), and generic abstractions (e.g., *color, size, time, manner*). Metaphoric "things" are nominalizations, namely, abstractions that derive from processes and qualities (e.g., *destruction, diversity*).

Specifically, Text 1 contains primarily concrete "things" (e.g., *I, Chloe, tram tracks*). The "things" of Texts 2–5 are mainly technical abstractions (e.g., *kinetics, mRNA isoforms, exons, cell, molecules, cyclins, enzymes, height, length, triangle, sum, square, hypotenuse*). Although some of these abstractions are nominalizations (e.g., *sum, square, length*), they are, in Martin's (1997) terms, intended to transcend the grammatical metaphors and carry on as technical objects in their own right. The "things" in Text 6, on the contrary, are primarily institutional abstractions and metaphoric abstractions. Institutional abstractions include terms such as *the National Association for the Advancement of Colored People (NAACP), Jim Crow laws, regulations, civil rights organizations, the Supreme Court, the federal government*, and *northern states*. Martin (1997, p. 31) referred to these as "bureaucratic ratchets" that organize people's lives. Even when concrete "things," such as historical figures, are used, they are often defined, individually or as a group, in their institutional roles as, for example, *Executive Secretary of NAACP, the white leaders in Southern states, political leaders, southern leaders, mourners, Northern agitators*, and *civil rights leaders*. Metaphoric abstractions in the text include *the kidnapping and murder of Emmett Till; the trial of his killers; the viewing of his disfigured corpse; outrage; the cold-blooded murder of this boy from Chicago; white supremacy; a racist act; the killing; the protests and condemnations; the 1954 Supreme Court decision Brown v. Board of Education of Topeka; integration of schools*; and *the two rulings*.

The institutional and metaphoric abstractions, together with semiotic abstractions (e.g., *the issue, the crime, the biggest news items of 1955, the racist attitudes*)

and generic abstractions (*an interview, the Southern way of life*), help create a world of abstractions in Text 6, which is contrary to the world of action and emotion depicted in Text 1 and the world of technicality and density conveyed in Texts 2–5. These abstractions enable the author to bundle together events over time into a package (*Jim Crow laws, the 1954 Supreme Court decision Brown v. Board of Education Topeka*); to ascribe judgment (*a racist act, the cold-blooded murder of this boy from Chicago, the viewing of his disfigured corpse*); and to expand information (*the cold-blooded murder of this boy from Chicago, the protests and condemnations from civil rights leaders and Northerners, the racist attitudes that led to it*). Clearly, it is primarily through these nominal structures that the historian was able to infuse his perspectives into the interpretation of the historical event, although other grammatical resources, such as verbs (e.g., *horrified, alarmed, condemned, poked, stinging, pushed, declared*), also contribute to the evaluation.

Another common feature of historical discourse is the way it construes causality and time. In the more commonplace language of everyday life, causality is typically realized between clauses through conjunctions such as *because* and *so*. In history, cause–effect is often realized in verbs (e.g., *lead to, ensue, make*), nouns (e.g., *reason, effect, response*), or prepositional phrases (e.g., *with, for, through, from*) (Coffin, 2006; Martin 2002; Schleppegrell 2004). For example, in the sentence, *The white leaders in Southern states… were still stinging from the 1954 Supreme Court decision Brown v. Board of Education of Topeka, which declared that racially segregated schools were unconstitutional*, the preposition "from" and the verb "declared" both imply causality, suggesting that it is the 1954 Supreme Court decision that caused the white leaders in the Southern states to feel pain (like getting stung) and that made racially segregated schools unconstitutional. In the sentence, *The grisly open-casket photo of Emmett … horrified and angered hundreds of thousands more*, the verbs "horrified" and "angered" suggest that it is the display of the grisly photo that caused many people to feel horrified and angry. The verb phrase "led to" in the sentence, *Newspapers across the country … condemned the killing and the racist attitudes that led to it*, construes not only causality (racist attitudes caused Emmet Till's killing) but also temporal sequence regarding the order of the events happening in real time (i.e., racist attitudes preceded the killing). Such within-clause logical reasoning necessitates the causes and effects of historical events to be constructed as abstract "things." Martin (2002) pointed out that, by construing causal relations within clauses rather than between clauses, historians have available to them a much wider array of linguistic resources—nouns, verbs, and prepositions, in addition to conjunctions—for delicately explaining how one thing leads to another. In so doing, however, they also make explanations and interpretations less accessible for students to comprehend and critique.

Summary

Disciplinary texts are an important vehicle for producing, storing, communicating, and evaluating knowledge in academic disciplines. The six sample texts, although not representing the whole range of texts that are available in academic subjects, demonstrate, nonetheless, some of the key features of disciplinary texts in secondary subject areas. These texts are constructed in characteristic patterns of language that present new forms, purposes, and processing demands. These language patterns are not just complexities that construct barriers to privilege content experts; they have evolved to meet the needs of particular disciplines, enabling content experts to perform their social, semiotic, and cognitive work. This suggests that disciplinary enculturation necessitates learning the language patterns that construct the knowledge, value, and worldview of the dis-

cipline. Students must develop facility with disciplinary ways of using language to become truly literate in the discipline.

SUPPORTING DISCIPLINARY LITERACY DEVELOPMENT THROUGH A FUNCTIONAL FOCUS ON LANGUAGE

As indicated at the outset of this article, developing literacy in the disciplines requires knowledge of both disciplinary language and disciplinary content. Because disciplinary content is accessed and assessed largely through language (and texts) in academic subjects, a focus on language in disciplinary learning is essential. In fact, the concept of disciplinary learning as primarily a linguistic process is, to borrow from Halliday (2007), "the best way we have of understanding, and therefore of intervening in, the directions and practices of education" (p. 96).

This article describes some of the language patterns in the texts from core academic disciplines and in so doing, identifies the language correlates of disciplinary literacy. Literacy instruction in the disciplines needs to recognize and respond to the challenges disciplinary language presents to students. It can no longer focus solely on the set of basic skills and generalized strategies that have so far characterized content area literacy instruction. The difficulties of disciplinary texts lie not just in words, but more broadly in the discourse grammar, or language patterns. As students move from thematically organized multidisciplinary units of work in early grades into specialized studies of academic subjects in secondary schools and beyond, the curriculum content with which they have to engage becomes more abstract, specialized, and complex; and so do the language and texts that construct this content.

The complex, yet distinct, grammatical patterning of disciplinary texts augurs a need for students to develop "the ability to handle language in new ways" (Christie, 1998, p. 57) and to develop literacy skills and strategies more embedded in the disciplines (Biancarosa & Snow, 2006). Specifically, literacy instruction in the disciplines needs to move beyond vocabulary instruction to include practices that help students recognize discipline-specific language patterns and develop their understanding of, as well as appreciation for, the varied ways language (with its lexis and grammar) constructs knowledge and construes value in different disciplines. It also needs to move away from an overemphasis on oral reading fluency. Fluency practices prize speed, prosody, and accuracy. They make great sense when teaching students to read texts with commonsense language and straightforward messages; however, they may not be as effective in dealing with the more complex texts of disciplinary learning. Comprehending disciplinary texts requires that readers pause periodically to analyze the language patterns in the text, sort out potential linguistic issues, and carry out deliberate conversations with the author. As Wineburg (1991) has argued in the context of history education, "the very act of comprehension demands that readers stop to talk with texts" and "participate actively in the fabrication of meaning" (p. 503). All of this cannot be hurried and likely takes time and effort, even for proficient readers.

Equally important, it is time for literacy instruction in the disciplines to move beyond the teaching of general cognitive strategies (e.g., predicting, inferencing) to embrace a stronger focus on disciplinary language. Students, with rare exceptions, typically have acquired general cognitive strategies by the time they enter school and use them effectively in their daily speaking–listening practices. There is no doubt that some teaching of these strategies can be beneficial to students with language-learning disabilities and comorbid difficulties. Such teaching also can be helpful in making all students aware that reading and writing, like speaking and listening, are active meaning-making processes. However, Hirsch (2005) cautioned against excessive teaching of these strategies, suggesting that students need knowledge of both disciplinary language and disciplinary content to apply the cognitive strategies they already possess (or, in the case of those with lan-

guage impairment, are developing) to help them make sense of disciplinary texts they read. Similarly, there is a need to rethink the perennial emphasis on generic learning strategies (e.g., note taking, highlighting). These strategies are not comprehension strategies; they are more like assessment tools that require readers to record or demonstrate what they have already comprehended. Effective use of these tools depends on the extent to which students are able to make sense of the texts they read. For example, it could be argued that when students do not complete a graphic organizer or two-column notes properly, it is more likely because they have not comprehended the text than because they do not know how to use the tools.

Recent works on adolescent literacy (e.g., Fang & Schleppegrell, 2010; Greenleaf, Schoenbach, Cziko, & Mueller, 2001; Jetton & Shanahan, 2012; Langer, 2011; Lee & Spratley, 2010; McConachie & Petrosky, 2010; Moje, 2008) have described several promising approaches to disciplinary literacy. A particular strand in this scholarship foregrounds the role of language in the development of disciplinary literacy. This work provides ways of accessing disciplinary content and cultivating disciplinary habits of mind through a functional focus on language. For example, Fang and Schleppegrell (2010) described a framework for engaging students in disciplinary learning through functional language analysis. Functional language analysis recognizes that disciplinary texts are constructed in patterns of language that adolescents often find unfamiliar and challenging. It offers teachers a set of practical tools for engaging students in systematically analyzing the language patterns and discussing the meanings of these patterns in disciplinary texts. The analysis and discussion focus on three key types of meaning that are important to all reading/writing: content, organization, and style/voice/tone. Students learn what a text is about by analyzing its patterns of verbs, nouns, adverbs, and prepositional phrases; they see how a text is organized by analyzing what begins each clause, how clauses are combined, or how cohesion is calibrated; and they uncover the author's perspective or how the author interacts with the reader by analyzing word choices. These functional language analysis tools enable students to learn about the characteristic language patterns that construct the texts of different disciplines at the same time they are learning disciplinary content and developing disciplinary habits of mind through language. Using functional language analysis, teachers can help students learn to recognize the patterns of language that construct knowledge and value in different ways across different school subjects, enabling adolescents to more effectively engage in the advanced literacy tasks of generating, communicating, evaluating, and renovating disciplinary knowledge.

To use functional language analysis effectively, students need sufficient exposure to disciplinary language through reading a wide variety of texts (e.g., textbooks, trade books, newspapers, magazines, journals, primary source documents, the Internet) in the discipline. They also need to develop an explicit understanding of the nature, structure, and function of disciplinary language. Related to this, Fang (2010) has described a number of tasks in the science education context that engage students in learning the language of science at the same time they are learning about the language of science. These tasks include morphemic analysis, noun deconstruction, noun expansion, noun search, definition game, paraphrasing, sentence combining, sentence completion, recognizing textual signposts, and syntactic anatomy and integration. They are designed to raise students' awareness of the features of the language of science, helping them to better cope with the challenges of science reading and writing. These tasks can be adapted for use in other disciplinary contexts (Fang, 2008, 2011) and for purposes of assessment and remedial instruction with students who are linguistically challenged or impaired (Scott & Balthazar, 2010).

CONCLUSION

Developing disciplinary literacy involves extending students' meaning potential through language. To engage effectively with disciplinary learning, students need to expand the repertoire of language skills they have developed during the early years of schooling, learning to recognize how language is used in different disciplines to present knowledge, give value, and create specialized texts. This new literacy ability is best developed in disciplinary contexts and with the help of teachers who are knowledgeable of both disciplinary content and disciplinary language, for it is through participation in discipline-specific practices of reading, writing, talking, inquiring, thinking, and reasoning that disciplinary knowledge and disciplinary habits of mind are used, shared, critiqued, refined, and expanded.

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