Syllable-Based Reading Strategy for Mastery of Scientific Information

ALPANA BHATTACHARYA

ABSTRACT

This article describes a strategic approach for reading and comprehending scientific information from a middle school science textbook. First, the word-reading skills of children with and without reading difficulties are compared. Second, studies investigating the effectiveness of a syllable-based reading approach on the word-reading skills of middle school children with reading difficulties are reviewed. Finally, the use of a syllable-based approach for reading and comprehending information from a middle school science textbook is described, with specific emphasis on learning words presented within and outside the context of text passages.

Successful comprehension of content-area texts requires that students read narrative-type passages involving multisyllabic vocabulary with considerable accuracy and fluency (Carnine & Carnine, 2004). Therefore, the ability to read words accurately and fluently is essential for meaningful comprehension of content-area texts. It is the ability to read words accurately and instantaneously that distinguishes children with and without reading difficulties (RD; Shippen, Houchins, Steventon, & Sarton, 2005; Stanovich, 1986). Because children without RD generally read words by breaking them down into syllables, their ability to recognize words is instantaneous and accurate (Mewhort & Beal, 1977). Deficient use of syllable structure, on the other hand, often compels children with RD to process letters rather than syllables within words, which then leads to erroneous reading of words (Scheerer-Neumann, 1981; Van Daal & Reitsma, 1990). *Syllabication*—the ability to parse words into pronounceable units—therefore, is an important strategy for word recognition (Shefelbine, Lipscomb, & Hern, 1989; Treiman, Bowey, & Bourassa, 2002) for children with and without RD.

The word-recognition ability of children with and without RD—especially their ability to recognize syllable units in polysyllabic words—has been investigated by several researchers in recent years. Casalis, Colé, and Sopo (2004), for example, compared the word-identification ability of children with and without developmental dyslexia by engaging them in a *Morphological Analysis Task* that required blending and segmenting of larger units like prefixes, suffixes, and roots of morphologically complex words like *unacceptable*, *acceptable*, and *acceptance*. The blending section of the *Morphological Analysis Task* required that children pronounce a morphologically complex word when given the base and the affix (e.g., *percent*- [base] and -*age* [affix] = *percentage* [word]). The segmentation section, on the other hand, required that children pronounce the base and affix of a morphologically complex word (e.g., *triumphant* [word] = *triumph*- [base] and -*ant* [affix]). Analysis of children's performance on the *Morphological Analysis Task* indicated that compared to children without developmental dyslexia, children with developmental dyslexia showed deficits in their ability to blend and segment letter units in words. Because morphological awareness requires an awareness of phonemes and syllable units in complex words (Mann, 2000), poor performance on the *Morphological Analysis Task* could be

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interpreted as low syllabication ability of children with developmental dyslexia.

In a preliminary exploration, Duncan and Seymour (2003) examined sixth-grade children's syllable awareness by asking them to divide 48 spoken bisyllabic words (e.g., *tortoise, beneath, hostage*) into two syllable segments (e.g., *tor-toise, be-neath, hos-tage*) and read 100 multisyllabic words (e.g., *commander, festival, gigantic,* and *symbolic*) presented in isolation on a computer screen. The results indicated that the 11-year-old readers had little difficulty with segmenting spoken bisyllabic words into two syllables and were reasonably accurate in their ability to read multisyllabic words. This suggests that word-reading accuracy depends on the decoding of syllable units in multisyllabic words.

To better understand readers' ability to read words based on their knowledge of the spelling patterns of words, Shefelbine and Calhoun (1991) also compared the word identification performances of sixth-grade children with and without RD by analyzing their use of syllables and letters in the process of reading difficult polysyllabic words. A standardized word reading test was administered, and participants' error responses for the last 10 words were analyzed to determine the extent to which readers attended to letters and syllables in unfamiliar polysyllabic words. Three types of analyses (syllable analyses, consonant analyses, and vowel analyses) were conducted and summarized in terms of percentages and ratios. Findings from the data analyses indicated that sixth-grade children without RD attended to and made efficient use of syllable, consonant, and vowel information in reading difficult polysyllabic words. They exhibited greater ability to attend to and use final syllables and suffixes and less instances of omitting syllables and vowels, adding consonants, and substituting words sharing visual spelling patterns. In comparison, sixth-grade children with RD used letter clusters and syllables at the beginning and ending of words to read unfamiliar words. A majority of their omissions and additions involved syllables, consonants, and vowels in the middle of words, and they made more real word substitutions as well.

As in the aforementioned studies, Marmurek (1988) examined second-, fourth-, and sixth-grade children's ability to attend to syllable units in two word-recognition tasks. The first task required participants to decide whether a target word matched a displayed word, and the second task asked participants to decide whether a single letter target matched the first letter of a displayed word. Compared to children without RD, children with RD across all grades were less able to shift attention to syllable components in their visual processing of words. These results suggest that children with RD exhibit word recognition problems due to deficient analyzing of syllable units within words. In sum, the results indicate that children without RD can successfully identify polysyllabic words by effortlessly attending to syllables and letters in words, whereas children with RD have problems in decoding words because they pay less attention to syllable units and letters within words.

Syllabication Studies and Word Reading Skills of Children With RD

The studies reviewed in the previous section suggest that compared to children without reading difficulties (RD), children with RD have significant problems reading words. More specifically, children with RD are slower and less accurate at reading words, and their word-recognition deficit stems from difficulty in analyzing letter clusters and syllables within words (Shefelbine, Lipscomb, & Hern, 1989). On the other hand, as most children can effortlessly identify syllables in spoken words and can intuitively divide unfamiliar words into syllables (Schell, 1967), researchers believe that the word-recognition deficits of children with RD can be improved with syllabication instruction (Archer, Gleason, & Vachon, 2003; Scheerer-Neumann, 1981). Instructional lessons, therefore, should focus on directing children's attention toward breaking polysyllabic words into manageable syllable segments (Duncan & Seymour, 2003) because polysyllabic words are represented in lexical memory as syllable units (Taft, 2002), and memory for syllable units facilitates the pronunciation of words (Moats, 2004a).

In a recent investigation, Shippen et al. (2005) examined the effectiveness of two reading programs, *Corrective Reading Decoding B2* and *C* (Engelmann, Johnson, et al., 1999; Engelmann, Meyer, Johnson, & Carnine, 1999) and *Reading Excellence: Word Attack and Rate Development Strategies* (REWARDS; Archer, Gleason, & Vachon, 2000), on the reading achievement of 55 struggling seventh-grade readers. Students randomly assigned to the *Corrective Reading Decoding* program were taught various sound–symbol relations and pronunciation of affixes (i.e., prefixes and suffixes), which they then used to decode words. For example, initially, students learned the sound–symbol relations for the prefix *im-* and the suffix *-ly*; then they read the affixes *im-* and *-ly* underlined in the word *impatiently*; and finally, they read the whole word, *impatiently*. Comparatively, students in the REWARDS program were taught a flexible decoding strategy. To begin with, students segmented a word (e.g., *production*) into parts by (a) circling the prefix (e.g., *pro-*), (b) circling the suffix (e.g., *-tion*), and (c) underlining the vowel sound (e.g., *duc*). Then the students said the parts (i.e., *pro*, *duc*, *tion*). Finally, they said the whole word (i.e., *production*). Two pretest and posttest measures, the *Test of Word Reading Efficiency* (Torgesen, Wagner, & Rashotte, 1999) and the *Gray Oral Reading Test* (Wiederholt & Bryant, 2001), were administered to determine the effectiveness of the two reading programs. The results indicated that students in both reading programs exhibited significant gains in their word-reading efficiency, reading rate, reading accuracy, and reading fluency after intervention. Both reading programs, however, exerted greater influence on students with higher scores on the pretest measures than on students with lower scores.

Bhattacharya and Ehri (2004) also investigated the effectiveness of syllable segmentation instruction on the word-reading ability of 60 junior high school and high school children from sixth- through 10th-grade classes. Participants were classified as low-level (third-grade-equivalent level) and high-level (fourth- or fifth-grade-equivalent levels) readers based on their word-reading scores on a standardized word reading test and randomly assigned to three groups: syllable, word, and control conditions. In a multistep word decoding process, syllable condition participants (a) read a polysyllabic word (*entertainment*); (b) divided the word's pronunciation into syllables, counted the number of syllables, and then pronounced and identified the spelling corresponding to the spoken syllables in print (*en-ter-tain-ment*); and (c) recombined the syllables to read the whole word (*entertainment*). In comparison, participants in the word condition read words as a whole, without segmenting them into syllables. Syllable and word condition participants learned to read 100 words during four 30-min practice trials. Participants in the control condition remained in their English classes and did not receive any training. Several pretest and posttest literacy measures were administered to assess the effect of syllable training on participants' ability to read familiar and unfamiliar words. The results indicated that syllable training significantly improved participants' ability to read words over time. This suggests that the ability to segment and blend words is essential for the accurate identification of polysyllabic words.

The effectiveness of another structured syllabication instruction system, *LANGUAGE!* (Greene, 1995), was investigated by Moats (2004b). A research-validated curriculum, *LANGUAGE!* focuses on developing adolescent poor readers' ability to recognize advanced level words through structured, systematic syllable recognition instruction. As a part of the *LANGUAGE!* curriculum, poor readers are provided with extensive practice in reading words, spelling words, and analyzing syllables in words. Six types of syllables—*closed* (e.g., dependent), *open* (e.g., starvation), *vowel combinations* (e.g., unspeakable), *r-controlled* (e.g., surrender), *vowel–consonant–e* (e.g., obsolete), and *consonant–le* (e.g., rumble)—are taught to familiarize older poor readers to the letter–sound relations for vowels within syllables of words (Archer et al., 2003; Moats, 2001). Moats (2004b) analyzed data related to the implementation of the *LANGUAGE!* curriculum in the Sacramento City Unified School District. Poor readers (N = 555) from 6th-, 7th-, 8th-, and 10th-grade classes received 270 hours of structured language instruction from September 1998 through May 1999. Three standardized tests were used as pretest and posttest measures—a spelling test (*Wide Range Achievement Test*, third edition), a comprehension test (*Multilevel Academic Survey Test*), and a decoding test (*Woodcock-Johnson Tests of Achievement*)—to determine the effect of the curriculum on reading and spelling achievement. Statistical analyses of poor readers' pretest and posttest performance indicated significant gains in word recognition and passage comprehension skills between September and May. This suggests that older poor readers' word recognition ability was amenable to syllabication instruction, and structured language instruction registered notable improvement in the comprehension skills of adolescents with below–grade-level reading skills.

Shefelbine (1990) also developed and tested an approach to syllabication instruction including (a) syllable automaticity (i.e., the ability to identify individual syllables accurately and rapidly) and (b) syllable pattern identification (i.e., the identification of letter clusters or subsyllabic units within polysyllabic words). Fourth- and sixth-grade children with RD were randomly assigned to a syllabic-unit instruction condition or to no special instruction condition. Over a 6-week period, children with RD in the syllabic-unit group were taught to decode familiar and unfamiliar real words with a syllable segmentation approach. Shefelbine's syllabication program included four core processes: (a) transformation (i.e., the ability to read open and closed syllable units; e.g., *om* and *mo* presented in sets such as *og-mog-mo*); (b) sight syllable practice (i.e., the ability to identify affixes and Latin roots on sight); (c) practice with real words (i.e., the ability to read polysyllabic words such as *reconstruction* syllable by syllable and as a whole word); and (d) division practice (i.e., the ability to decode unfamiliar polysyllabic words by analyzing syllabic units in words). Children in the control condition remained in their traditional language arts classes and received no special instruction. Comparison of the children's performance on two standardized word reading tests indicated that children in the training group made greater progress in their ability to identify words than the children who received no special instruction. Based on the results, Shefelbine (1990) contended, "Directly teaching students how to pronounce and identify syllable units and then showing them how such units 'work' in polysyllabic words appears to be a worthwhile component of syllabication instruction and should help reduce or remediate this source of reading difficulty among intermediate students" (p. 228).

Children with RD in the intervention studies just reviewed practiced the application of syllabication strategy by reading words in isolation. Syllabication instruction, however, could also be extended to reading words in context, because the mastery of content-area information, particularly in Grades 5 to 8, requires the reading of textbooks and supplementary literature. Accordingly, this article describes an instructional process wherein middle school children learn the application of Bhattacharya and Ehri's (2004) syllabication strategy to read information presented in a designated science textbook. Specifically, the purpose of this article is to promote intermediate-grade students' knowledge of science content delineated by the *New York State Learning Standards for Science* through syllabication strategy instruction.

Syllable-Based Strategy Instruction for Scientific Reading

The *Intermediate-Level Science Examination: Test Sampler Draft* (University of the State of New York, 2000) assesses middle school children's achievement of Standards 1, 2, 4, 6, and 7 of the *Learning Standards for Mathematics, Science, and Technology* (University of the State of New York, 1996). The *Intermediate-Level Science Examination: Test Sampler Draft* includes a 2-hour written examination and a 1-hour laboratory performance examination. The written examination contains four parts: multiple choice items, constructed response items, extended constructed response items, and laboratory performance items. The multiple choice items (Part A), consisting of approximately 25% to 35% content-based questions, assess middle school children's knowledge and understanding of core material primarily from Standard 4 of the *Learning Standards for Mathematics, Science, and Technology*. The constructed response items (Part B), including approximately 25% to 35% content- and skill-based questions, assess middle school children's ability to apply, analyze, and evaluate material primarily from Standards 1 and 4 of the *Learning Standards for Mathematics, Science, and Technology.* The extended constructed response items (Part C), consisting of approximately 20% to 25% content and application questions, assess middle school children's ability to apply knowledge of scientific concepts, formulate hypotheses, make predictions, and use other scientific inquiry skills to address real-world situations primarily from Standards 1, 2, 4, 6, and 7 of the *Learning Standards for Mathematics, Science, and Technology*. The laboratory performance test (Part D) questions require middle school children to graph, complete data tables, draw sketches, label diagrams, design experiments, formulate hypotheses, make calculations, or write responses based on their ability to hypothesize, interpret, analyze, and evaluate data presented in diagrams for three laboratory settings, Stations X, Y, and Z.

All middle school children, as specified in the test sampler draft, are required to answer all questions on the *Intermediate-Level Science Examination* because "in accordance with the Commissioner's Regulation 100.2, students who score below the state designated performance level on the Intermediate-Level Science Examination must be provided academic intervention services (AIS) by their school by the start of the next school year" (University of the State of New York, 2000, p. 2). This stipulation also applies to students with disabilities in Grades 5 through 8 who, however, are entitled to test modifications documented in their Individualized Education Program (IEP) or Section 504 Accommodation Plan. Appendix B of the *Intermediate-Level Science Examination*, Reference to Intermediate-Level Science Core Curriculum, Grades 5–8, included in the test sampler draft, provides an overview of the relationship between specific test items and the intermediate-level core curriculum that could help teachers in both general and special education to identify specific areas of the core curriculum in which middle school students might need additional instruction, to plan instructional activities requiring higher order thinking skills, and to teach test-taking strategies to increase the option of receiving better scores on the new science assessment. Furthermore, as several items of the *Intermediate-Level Science Examination: Test Sampler Draft* require the reading and writing of polysyllabic words (i.e., words with three, four, and five syllables), teachers could help students—particularly those with RD—to perform effectively on the science examination by including a syllabication approach to reading in their instructional plan, in addition to teaching higher order thinking skills and test-taking strategies.

The stems (i.e., questions) and the alternatives (i.e., answers) of multiple choice items (Part A, Questions 1–17) in the *Intermediate-Level Science Examination: Test Sampler Draft* (see University of the State of New York, 2000, pp. 3–7) include several polysyllabic words, such as *hereditary*, *reproduction*, *photosynthesis*, *metamorphosis*, *regulation*, *fertilization*, *respiration*, *circulatory*, *cementation*, *sedimentation*, *crystallization*, *evaporation*, *precipitation*, *condensation,* and *phenomenon*, that middle school students have to read prior to selecting an accurate response. In the following multiple choice item, for example, middle school students, including those with RD, have to read 10 polysyllabic words (i.e., four 3-syllable words, one 4-syllable word, four 5-syllable words, and one 6-syllable word) out of a total of 22 words to select the correct answer:

> Which two processes result in the formation of igneous rocks?
>
> 1. melting and solidification
> 2. sedimentation and evaporation
> 3. crystallization and cementation
> 4. compression and precipitation (University of the State of New York, 2000, Part A, p. 6)

Unless students can accurately and instantaneously read the polysyllabic words included in the alternatives and the stem of this sample multiple choice item, they may fail to select the correct answer not because of their insufficient scientific knowledge, but because of their difficulty in reading polysyllabic words. To facilitate the accurate decoding of polysyllabic words, both in context (i.e., the stem) and in isolation (i.e., the alternatives) of multiple choice items, teachers could include the research-supported syllabication reading approach designed by Bhattacharya and Ehri (2004) in their science instructional program.

The constructed response (Part B, Questions 18–34), extended constructed response (Part C, Questions 35–45), and laboratory performance (Part D, Stations X, Y, and Z) sections of the *Intermediate-Level Science Examination: Test Sampler Draft* (University of the State of New York, 2000) require written responses to questions based on scientific information presented in diagrams, charts, graphs, and data tables. Like the multiple choice items, the questions and the diagrams, charts, graphs, and data tables in the constructed response items (Part B, pp. 8–13), the extended constructed response items (Part C, pp. 14–17), and the laboratory performance items (Part D, pp. 39–45) of the test sampler also require students to read polysyllabic words, such as *approximately*, *transformations*, *represented*, *pollination*, *observations*, *variables*, *temperatures*, *laboratory*, *population*, *hypothesis*, *experiment*, *calculations*, *diagonally*, and *estimated*, prior to producing written responses. For instance, to generate a written response for the extended constructed response Item 42 on page 16 of the Test Sampler, "Based on your graph, predict the population density of organism A or organism B at Day 21. Explain your prediction," middle school students would have to accurately read the polysyllabic words *density*, *population*, *organism*, and *prediction*. Difficulty in reading the target polysyllabic words in this extended constructed response item could inhibit students' ability to generate an effective written response. Again, teachers could ensure the accurate and instantaneous recognition of polysyllabic words by incorporating the Bhattacharya and Ehri (2004) syllabication strategy into the reading of scientific information from textbook passages.

Standard 4 of the *Learning Standards for Mathematics, Science, and Technology* (University of the State of New York, 1996) stipulates that "students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science" (p. 1). Accordingly, this article proposes syllabication instruction for enhancing students' understanding of scientific information. The textbook *Life Science* (Biggs, Daniel, Ortleb, Rillero, & Zike, 2002) has been selected for a demonstration of the Bhattacharya and Ehri (2004) syllabication strategy in the context of the scientific topic *Cell Structure*. Content objectives 1, 3, 4, and 5, listed in Standard 4 of the *Learning Standards for Mathematics, Science, and Technology* (p. 33), are pertinent to the understanding of *Cell Structure*; therefore, the syllabication instruction proposed in this article focuses on middle school students' learning of scientific concepts and attainment of curricular standards. The proposed syllabication strategy is applied to two types of word reading processes—reading words within and reading words outside the context of textbook passages—through teacher modeling, guided practice, and independent practice in reading polysyllabic words.

Syllabication Instruction for Reading Words Out of Context

Prior to beginning classroom instruction on the application of the Bhattacharya and Ehri (2004) syllabication strategy for reading words outside the context of text passages, teachers could select polysyllabic words from a designated science textbook. The Appendix presents 60 polysyllabic words drawn from the textbook *Life Science* (Biggs et al., 2002, p. 38–45). The words drawn from textbook passages could be classified into two language categories as specified by Snow, Met, and Genesee (1989): content-obligatory language and content-compatible language. *Content-obligatory* language refers to language that is essential for understanding a given content, and *content-compatible* language refers to language that can be taught in the context of a given content but is not required for successful mastery of the content. For example, in order for students to understand the scientific concepts of *Cell Structure*, mastery of content-obligatory words like *cytoplasm*, *organelle*, *nucleolus, mitochondrion*, and *ribosome* is essential. In contrast, students could learn content-compatible words like *dynamic*, *responsible*, *manufacture*, *communicate*, and *temporary* in the context of the scientific concept of *Cell Structure*, but knowledge of these words is not required for mastery of the targeted content.

Teacher Modeling

Teachers could select 10 content-obligatory and 10 content-compatible words from the list of 60 words (see the Appendix) to demonstrate the application of the syllabication approach. To begin with, teachers would read aloud a polysyllabic word printed on construction paper, chart tablet, or transparency (e.g., *prokaryotic*). Next, teachers would explain the word (e.g., "Cells without membrane-bound structures are called prokaryotic cells"). Then, teachers would divide the word into syllables and pronounce the segments (e.g., *pro/kary/o/tic*). Finally, teachers would say the word aloud (e.g., *prokaryotic*). Teachers would repeat the demonstration of the syllabication strategy with additional words to ensure that students understood the process of reading polysyllabic words by dividing them into syllables.

Guided Practice

Following teacher modeling of the syllabication approach, students should be provided with guided practice in reading 10 content-obligatory and 10 content-compatible words through whole-group syllabication of words. The selected words would exclude words from the teacher modeling phase of syllabication instruction. To facilitate accurate and instantaneous reading of words through application of the syllabication approach, teachers could provide the following prompt card listing the steps inherent in the syllabication process:

R = READ word (e.g., *carbohydrate*)

E = EXPLAIN meaning (e.g., an organic compound made of carbon, hydrogen, and oxygen)

D = DIVIDE word (e.g., *car/bo/hy/drate*)

S = SAY word (e.g., *carbohydrate*)

Teachers could begin the guided practice phase of syllabication instruction by writing a specific word on the chalkboard and then randomly selecting individual students from the whole class to read the word aloud, define the word, and syllabicate the word. Teachers could acknowledge students' accurate syllabication and word reading performances with verbal praise and offer corrective feedback for inaccurate performances. For example, if a student divides the word *capillaries* as *cap/il/laries*, the teacher could say, "Watch me divide the word into syllables and then you try it." The teacher would segment a word into syllables, *cap/il/lar/ies*, then direct the student to divide the word by saying, "Now you try it." Correct syllabication would be acknowledged with verbal praise like, "You divided the word correctly. Good work."

Independent Practice

Independent practice in segmenting and reading words would be an extension of guided practice. Teachers could provide individual students with a worksheet consisting of 10 content-obligatory and 10 content-compatible words as a "do now" activity. The 20 selected words would be different from those included in the teacher modeling and guided practice phases of syllabication instruction. To facilitate the precise reading and syllabication of words, students could be instructed to use the mnemonic REDS, which would alert them to R = Read a word, E = Explain a word, D = Divide a word, and S = Say a word.

Syllabication Instruction for Reading Words In Context

This section of the syllabication instruction emphasizes the reading of content-obligatory and content-compatible words within text passages. As middle school students would have mastered the application of the Bhattacharya and Ehri (2004) syllabication strategy to read words out of context earlier, teachers could then teach the reading of words in the context of text passages. Selected passages from a science textbook could be used for the generalization of the syllabication approach from reading words in isolation to reading words in context. Teachers could engage middle school children in silent and oral reading processes to promote accurate and instantaneous reading of scientific information through the application of syllabication. As a whole-class or individualized reading assignment, teachers could distribute copies of text passages with the polysyllabic content-obligatory and content-compatible words underlined and instruct the students to read the scientific information by applying the syllabication strategy.

For example, teachers could distribute the following passage, with the underlined content-obligatory and content-compatible words, from the textbook *Life Science* and instruct students to read the underlined words by applying the syllabication strategy:

> Cells make their own proteins on small structures called ribosomes. Even though ribosomes are considered organelles, they are not membrane bound. Some ribosomes float freely in the cytoplasm; and others are attached to the endoplasmic reticulum. Ribosomes are made in the nucleolus and move out into the cytoplasm. Ribosomes receive directions from the hereditary material in the nucleus on how, when, and in what order to make specific proteins. (Biggs et al., 2002, p. 42)

Students' attempts at reading the text passages through the application of the syllabication strategy could be monitored through teacher questions, student responses, and whole-class or individualized discussions. Accuracy of performance could be acknowledged through class consensus and incorrect syllabication of polysyllabic words could be modified through peer–peer and teacher–student corrective feedback. Such evaluation could pinpoint students' existing understanding of the syllabication strategy and their readiness to progress from the reading of familiar to unfamiliar words in text passages.

Because the underlined words in the passage illustrated earlier would have been practiced in the out-of-context word-reading phase of syllabication instruction, the students should be able to read the polysyllabic words instantaneously and accurately. Fluent and accurate recognition of content-obligatory and content-compatible words would also facilitate the comprehension of scientific information included in text passages and lead to improved performance on the multiple choice, constructed response, and extended constructed response items of the *Intermediate-Level Science Examination: Test Sampler Draft* (University of the State of New York, 2000).

Syllabication Instruction and Mastery of Scientific Information

The effectiveness of the Bhattacharya and Ehri (2004) syllabication strategy on middle school students' learning of scientific concepts could be determined through the administration of the *Intermediate-Level Science Examination: Test Sampler Draft* (University of the State of New York, 2000). The response to the following multiple choice item, for example, would indicate whether students were successfully applying the syllabication strategy:

> Hereditary information is found in a cell's
>
> 1. chloroplasts
> 2. chromosomes
> 3. cytoplasm
> 4. membranes (University of the State of New York, Part A, p. 3)

This multiple choice item contains two content-compatible words (i.e., *hereditary* and *information*) and four content-obligatory words (i.e., *chloroplasts*, *chromosomes*, *cytoplasm*, and *membranes*). The selection of the correct alternative (i.e., *chromosomes*) could indicate accurate reading and comprehension of content-compatible and content-obligatory words in the stem and the alternatives of the multiple choice item through the effective application of the syllabication strategy. Conversely, the incorrect selection of an alternative could suggest difficulty in reading and comprehending polysyllabic words due to the ineffective application of the syllabication strategy. As students would have mastered the content-obligatory words (e.g., *chloroplasts*, *chromosomes*, *cytoplasm*, and *membranes*) and the content-compatible words (e.g., *hereditary* and *information*) during the two reading phases (reading words in and out of context), they should be able to apply the syllabication strategy for reading and comprehending words in the multiple choice item and select the required response to demonstrate mastery of the concept of *Cell Structure*.

Conclusion

Accurate and fluent decoding of words is essential for the effective reading of content-area information. A large number of secondary-grade students, however, experience significant difficulty with decoding polysyllabic words, which in turn interferes with their ability to read, interpret, and respond to traditional paper-and-pencil assessment measures such as multiple choice items. Secondary-grade students often fail to appropriately demonstrate their understanding of content information on paper-and-pencil assessments, not because of an inadequate mastery of concepts, but because of their difficulty with deciphering test items like the stem and alternatives of a multiple choice item (Lorsbach, Jinks, & Templeton, 2004). Adolescent poor readers, therefore, require explicit instruction focused on developing their ability to recognize syllable units in polysyllabic words. Rather than teaching complex rules for dividing words into perfect dictionary syllables, reading instruction should focus on the application of a multistep decoding strategy (Archer, Gleason, & Vachon, 2003; Bhattacharya & Ehri, 2004), wherein struggling readers (a) orally divide a polysyllabic word (e.g., *transportation*) into variable syllable segments (e.g., *trans-port-a-tion*, *tran-sport-a-tion*, *trans-por-ta-tion*, or *tran-spor-ta-tion*), (b) underline or circle individual syllable segments, (c) pronounce each syllable segment, and (d) read the whole word. Lessons focused on adolescent poor readers' need to learn spelling patterns and word structure "can improve word recognition and make up lost ground in vocabulary, text reading fluency, and comprehension of 'book' language such as complex sentences and figures of speech" (Moats, 2004b, pp. 145–146). ■

ALPANA BHATTACHARYA, PhD, is an assistant professor of educational psychology at Queens College of the City University of New York. Her current research interests include reading strategies, writing processes, adolescents with learning disabilities, and educational technology. Address: Alpana Bhattacharya, Department of Secondary Education and Youth Services, Queens College of CUNY, 6530 Kissena Boulevard, Flushing, NY 11367-1597; e-mail: abhattac@qc1.qc.edu

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Appendix
Syllabication Instruction Word List

Content-Obligatory Words

1. gelatin
2. cytoplasm
3. bacterium
4. prokaryotic
5. eukaryotic
6. nucleolus
7. flagellum
8. ribosomes
9. organelles
10. carbohydrate
11. cellulose
12. molecules
13. cytoskeletons
14. chromosomes
15. chloroplast
16. cellular
17. vesicles
18. vacuoles
19. arteries
20. capillaries
21. cardiovascular
22. circulatory
23. respiratory
24. muscular
25. organisms
26. lysosomes
27. endoplasmic
28. reticulum
29. mitochondrion
30. chlorophyll

Content-Compatible Words

1. dynamic
2. hereditary
3. extensions
4. delicatessen
5. customers
6. responsible
7. protective
8. regulates
9. interactions
10. environment
11. manufacture
12. processing
13. communicate
14. singular
15. information
16. digestive
17. aluminum
18. promotional
19. encourage
20. chemicals
21. organized
22. illustrations
23. differences
24. similarities
25. interpreting
26. transporting
27. refrigerators
28. temporary
29. ingredients
30. disintegrates

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