Technical Guide

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Introduction

Introduction

The *Reading Inventory*, developed by Scholastic Inc., is an objective assessment of a student's reading ability (Scholastic, 2006a and 2007). The *Reading Inventory* consists of two subtests, the Foundational Reading Assessment and the Reading Comprehension Assessment. The Foundational Reading Assessment can be used to assess the development of early literacy skills for students in Grades K–2, including phonological awareness, letter-sound and letter-word identification, decoding, and sight word recognition. The Reading Comprehension Assessment can be used to assess the development of reading comprehension, to match students with appropriate texts for successful reading experiences, and to provide students with "stretch" reading experiences aligned with college and career readiness with appropriate scaffolding. The Reading Comprehension Assessment is appropriate for students in Grades 1–12 and is based on the Lexile Framework® for Reading.

Using the results reported by the *Reading Inventory*, teachers and administrators can:

- Identify struggling readers
- Plan for instruction
- Gauge the effectiveness of curriculum and instructional programs
- Demonstrate accountability

The *Reading Inventory* was initially developed in 1998 and 1999 as a print-based assessment of reading comprehension. In late 1998, Scholastic began developing a computer-based version. Pilot studies of the computer application were conducted in Fall and Winter 1998. Version 1 of the *Reading Inventory* was launched in Fall 1999. Subsequent versions were launched between 1999 and 2006, with version 4.0/Enterprise Edition appearing in Winter 2006. The *Reading Inventory* was developed in 2013 and launched in 2014. The Foundational Reading Assessment subtest was added to the *Reading Inventory* version for students in Grades K–2 who are still developing the foundational reading skills necessary for reading comprehension. The Foundational Reading Assessment was originally developed by Richard K. Wagner as a screener and placement assessment for *iRead*, a K–2 digital foundational reading program.

This technical guide for the *Reading Inventory* is intended to provide users with the broad research foundation essential for deciding if and how the *Reading Inventory* should be used and what kinds of inferences about readers and texts can be drawn from the results. The *Reading Inventory Technical Guide* is the latest in a series of technical publications describing the development and psychometric characteristics of the *Reading Inventory*. The first *Reading Inventory Technical Guide* (1999) described the development and validation of the print version, and a later *Technical Guide* (2007) described the development and validation of the Enterprise Edition. Subsequent publications will be forthcoming as additional data become available.

Features of the *Reading Inventory*

The *Reading Inventory* is designed to measure how well readers can read and comprehend literary and expository texts.

The Foundational Reading Assessment subtest of the *Reading Inventory* measures foundational reading skills by focusing on the skills readers use to fluently decode text. These skills include phonological awareness, letter-sound and letter-word identification, decoding, and sight word recognition. The purpose of the Foundational Reading Assessment subtest of the *Reading Inventory* is to ascertain a student's proficiency with foundational reading skills in order to determine his or her readiness for reading comprehension instruction.

The Reading Comprehension Assessment subtest of the *Reading Inventory* measures reading comprehension by focusing on the skills readers use to understand written materials sampled from various content areas. These skills include referring to details in the passage, drawing conclusions, and making comparisons and generalizations. The Reading Comprehension Assessment is composed of passages that are typical of the materials students read both in and out of school, including topics in prose fiction, the humanities, social studies, science, and everyday texts such as magazines and newspapers. The purpose of the Reading Comprehension Assessment subtest of the *Reading Inventory* is to locate the reader on the Lexile Framework Map for Reading (see Appendix A) and monitor development in reading. Once a reader has been measured, it is possible to forecast how well the reader will likely comprehend hundreds of thousands of texts that have been analyzed using the Lexile® metric.

Noteworthy features of the *Reading Inventory*:

- The *Reading Inventory* is a full-range instrument capable of accurately measuring reading ability from kindergarten to college.
- The test format supports quick administration in an un-timed, low-pressure format.
- Little specialized preparation is needed to administer the *Reading Inventory*, though proper interpretation and use of the results of the Reading Comprehension Assessment requires knowledge of the Lexile Framework.

Foundational Reading Assessment features:

- The Foundational Reading Assessment subtest is a multistage set of testlets that may be administered to a student up to three times. It applies discontinue criteria logic such that once a student has answered a set number of questions incorrectly, the student is advanced to the next subsection of the assessment.
- The Foundational Reading Assessment utilizes "hybrid" scores that combine accuracy and speed of responding. Hybrid scores, or fluency scores, are effective in that individual and developmental differences in an underlying reading skill affect both accuracy and speed of response. Therefore, a fluency score that incorporates both speed and accuracy is better than one that is based on only speed or accuracy.
- Performance on the Foundational Reading Assessment can be linked to DIBELS Next benchmark levels and percentile scores.
- The Foundational Reading Assessment can be divided into three strands that measure Phonological Awareness, Letter-Word Identification, and Word Attack. The Phonological Awareness Strand measures students' rhyme identification skills and students' ability to identify initial, final, and medial sounds. The Letter-Word Identification Strand measures students' knowledge of uppercase and lowercase letter names and their sight word knowledge. The Word Attack Strand measures students' ability to identify letter sounds, as well as their decoding skills.

Reading Comprehension Assessment features:

- The Reading Comprehension Assessment subtest employs a computer-adaptive algorithm to adapt the test to the specific level of the reader. This methodology continuously targets the reading level of the student, thus allowing for more precise measurements.
- The Reading Comprehension Assessment subtest applies a Bayesian scoring algorithm that uses past performance to predict future performance. This methodology connects each test administration to every other administration to produce more precise measurements when compared with independent assessments.
- The "embedded completion" item format used by the Reading Comprehension Assessment subtest of the *Reading Inventory* has been shown to measure the same core reading competency measured by norm-referenced, criterion-referenced, and individually administered reading tests (Stenner, Smith, Horiban, & Smith, 1987a).
- A decade of research defined the rules for sampling text and developing embedded completion items for the Reading Comprehension Assessment subtest. A multistage review process ensured conformity with item-writing specifications.
- The Reading Comprehension Assessment subtest of the *Reading Inventory* is the first and only among available reading tests in using the Lexile Theory to convert a raw score (number correct) into the Lexile metric. The equation used to calibrate the *Reading Inventory* test items is the same equation used to measure texts. Thus, readers and texts are measured using the same metric.
- The majority of the reading passages on the Reading Comprehension Assessment are authentic: they are sampled from best-selling literature, curriculum texts, and familiar periodicals. Some passages below 400L were commissioned to fit the assessment specifications.

Purposes and Uses of the *Reading Inventory*

The *Reading Inventory* is designed to assess the development of early literacy skills for students in Grades K–2, as well as to measure the ability to comprehend narrative and expository texts of increasing difficulty for students in Grades 1–12. The *Reading Inventory* measures students' reading growth from kindergarten to Grade 12 by utilizing two subtests:

Foundational Reading Assessment: A progress monitor to assess the development of early reading skills for students in Grades K–2, including phonological awareness, letter-sound and letter-word identification, decoding, and sight word recognition. Students receive a raw accuracy score and a raw fluency score. Fluency scores are linked to DIBELS Next benchmark levels and percentile scores.

Reading Comprehension Assessment: A reading comprehension assessment for students across Grades 1–12. Items contain authentic literary and informational text passages that students are likely to encounter both in and out of school. Test items are drawn from a variety of content areas. Test items do not require prior knowledge of ideas outside the passage, do not test on vocabulary taken out of context, and do not require formal logic. Scores are reported in Lexile measures.

Students are generally well measured when they are administered a test that is targeted near their true reading ability. When students take poorly targeted tests, there is considerable uncertainty about their locations on the Lexile Map. The Reading Comprehension Assessment's highest-level item passages are sampled from high school (and more difficult) literature and other print materials; a number of the lowest-level item passages are sampled from beginning first-grade literature, while other early-grades passages were specifically written for the Reading Comprehension Assessment. Figure 1 shows an example of an 800L item from the Reading Comprehension Assessment.

FIGURE 1. An example of a Reading Comprehension Assessment test item.

Wilbur likes Charlotte better and better each day. Her campaign against insects seemed sensible and useful. Hardly anybody around the farm had a good word to say for a fly. Flies spent their time pestering others. The cows hated them. The horses hated them. The sheep loathed them. Mr. and Mrs. Zuckerman were always complaining about them and putting up screens.

Everyone _____ about them.

A. agreed C. laughed

B. gathered D. learned

From *Charlotte's Web* by E. B. White.

Readers and texts are measured using the same Lexile metric, making it possible to directly compare reader and text. When reader and text measures match, the Lexile Framework forecasts 75% comprehension. The operational definition of 75% comprehension is that given 100 items written to assess comprehension of a text, the reader will be able to correctly answer 75. When a text has a Lexile measure 250L higher than the reader's measure, the Lexile Framework forecasts 50% comprehension. When the reader measure exceeds the text measure by 250L, the forecasted comprehension is 90%.

Limitations of the *Reading Inventory*

A well-targeted *Reading Inventory* Reading Comprehension Assessment can provide useful information for matching texts and readers. The *Reading Inventory*, like any other assessment, is just one source of evidence about a student's reading ability. Obviously, decisions are best made when using multiple sources of evidence about a reader. Other sources include other reading-test data, reading-group placement, lists of books read, and, most importantly, teacher judgment. One measure of reader performance, taken on one day, is not sufficient to make high-stakes student-level decisions such as summer-school placement or retention.

When considering the Foundational Reading Assessment subtest, it is important to note that it was originally developed as a screener and placement assessment for *iRead*, a K–2 digital foundational reading program. When using the Foundational Reading Assessment as a progress monitor, Houghton Mifflin Harcourt encourages users to employ multiple measures in deciding a student's level of proficiency with foundational reading skills.

When considering the Reading Comprehension Assessment subtest, the Lexile Framework provides a common metric for combining different sources of information about a reader into a best overall judgment of the reader's ability expressed in the Lexile metric. Houghton Mifflin Harcourt encourages users of the Reading Comprehension Assessment subtest to employ multiple measures when deciding where to locate a reader on the Lexile scale.

Theoretical Framework

Theoretical Framework of Reading Ability and the Lexile Framework in Support of the Reading Comprehension Assessment

All symbol systems share two features: a semantic component and a syntactic component. In language, the semantic units are words. Words are organized according to rules of syntax into thought units and sentences (Carver, 1974). In all cases, the semantic units vary in familiarity and the syntactic structures vary in complexity. The complexity (or difficulty) of a message is dominated by the familiarity of the semantic units and by the complexity of the syntactic structures used in constructing the message.

Readability Formulas and Reading Levels

Readability Formulas. Readability formulas have been in use for more than 60 years. These formulas are generally based on a theory about written language and use mathematical equations to calculate text difficulty. While each formula has discrete features, nearly all attempt to assign difficulty based on a combination of semantic (vocabulary) features and syntactic (sentence-length) features. Traditional readability formulas are all based on a simple theory about written language and a simple equation to calculate text difficulty.

Unless users are interested in conducting research, there is little to be gained by choosing a highly complex readability formula. A simple, two-variable formula is sufficient, especially if one of the variables is a word or semantic variable and the other is a sentence or syntactic variable. Beyond these two variables, more data adds relatively little predictive validity while increasing the application time involved. Moreover, a formula with many variables is likely to be difficult to calculate by hand.

The earliest readability formulas appeared in the 1920s. Some of them were esoteric and primarily intended for chemistry and physics textbooks or for shorthand dictation materials. The first milestone that provided an objective way to estimate word difficulty was Thorndike's *The Teacher Word Book,* published in 1921. The concepts discussed in Thorndike's book led Lively and Pressey in 1923 to develop the first readability formula based on tabulations of the frequency with which words appear. In 1928, Vogel and Washburne developed a formula that took the form of a regression equation involving more than one language variable. This format became the prototype for most of the formulas that followed. The work of Washburne and Morphett in 1938 provided a formula that yielded scores on a grade-placement scale. The trend to make the formulas easy to apply resulted in the most widely used of all readability formulas—Flesch's Reading Ease Formula (1948). Dale and Chall (1948) published another two-variable formula that became very popular in educational circles. Spache designed his renowned formula using a word-list approach in 1953. This design was useful for Grades 1–3 at a time when most formulas were designed for the upper grade levels. That same year, Taylor proposed the cloze procedure for measuring readability. Twelve years later, Coleman used this procedure to develop his fill-in-the-blank method as a criterion for his formula. Danielson and Bryan developed the first computer-generated formulas in 1963. Also in 1963, Fry simplified the process of interpreting readability formulas by developing a readability graph. Later, in 1977, he extended his readability graph, and his method is the most widely used of all current methods (Klare, 1984; Zakaluk & Samuels, 1988).

Two often-used formulas—the Fog Index and the Flesch-Kincaid Readability Formula—can be calculated by hand for short passages. First, a passage that contains 100 words is selected. For a lengthy text, several different 100-word passages are selected.

For the Fog Index, first the average number of words per sentence is determined. If the passage does not end at a sentence break, the percentage of the final sentence to be included in the passage is calculated and added to the total number of sentences. Then, the percentage of "long" words (words with three or more syllables) is determined. Finally, the two measures are added together and multiplied by 0.4. This number indicates the approximate Reading Grade Level (RGL) of the passage.

For the Flesch-Kincaid Readability Formula, the following equation is used:

RGL = 0.39 × (average number of words per sentence) + 11.8 × (average number of syllables per word) – 15.59

For a lengthy text, using either formula, the RGLs are averaged for the several different 100-word passages.

Another commonly used readability formula is ATOS™ for Books, developed by Advantage Learning Systems. ATOS is based on the following variables related to the reading demands of text: words per sentence, characters per word, and average grade level of the words. ATOS uses whole-book scans instead of text samples, and results are reported on a grade-level scale.

Guided Reading Levels. Within the Guided Reading framework (Fountas & Pinnell, 1996), books are assigned to levels by teachers according to specific characteristics. These characteristics include the level of support provided by the text (e.g., the use and role of illustrations, the size and layout of the print) and the predictability and pattern of language (e.g., oral language compared to written language). An initial list of leveled books is provided so teachers have models to compare when leveling a book.

For students in Grades K–3, there are 18 Guided Reading Levels, A through R (kindergarten: Levels A–C; first grade: Levels A–I; second grade: Levels C–P; and third grade: Levels J–R). The books include several genres: informational texts on a variety of topics, "how to" books, mysteries, realistic fiction, historical fiction, biography, fantasy, traditional folk and fairy tales, science fiction, and humor.

How Do Readability Formulas and Reading Levels Relate to Readers? The previous section described how to level books in terms of grade levels and reading levels based on the characteristics of the text. But how can these levels be connected to the reader? Do we say that a reader in Grade 6 should read only books whose readability measures between 6.0 and 6.9? How do we know that a student is reading at Guided Reading Level G, and when is he or she ready to move on to Level H? What is needed is some way to put readers on these scales.

To match students with readability levels, their "reading" grade levels need to be determined, which is often not the same as their "nominal" grade levels (the grade levels of the classes they are in). On a test, a grade equivalent (GE) is a score that represents the typical (mean or median) performance of students tested in a given month of the school year. For example, if Alicia, a fourth-grade student, obtained a GE of 4.9 on a fourth-grade reading test, her score is the score that a student at the end of the ninth month of fourth grade would likely achieve on that same reading test. But there are two main problems with grade equivalents:

1. *How grade equivalents are derived determines the appropriate conclusions that may be drawn from the scores.* For example, if Stephanie scores 5.9 on a fourth-grade mathematics test, it is not appropriate to conclude that Stephanie has mastered the mathematics content of the fifth grade (in fact, it may be unknown how fifth-grade students would perform on the fourth-grade test). It certainly cannot be assumed that Stephanie has the prerequisites for sixth-grade mathematics. All that is known for certain is that Stephanie is well above average in mathematics.

2. *Grade equivalents represent unequal units.* The content of instruction varies somewhat from grade to grade (as in high school, where subjects may be studied for only one or two years), and the emphasis placed on a subject may vary from grade to grade. Grade units are unequal, and these inequalities occur irregularly in different subjects. A difference of one grade equivalent in elementary school reading (2.6 to 3.6) is not the same as a difference of one grade equivalent in middle school (7.6 to 8.6).

To match students with Guided Reading Levels, the teacher makes decisions based on observations of what the child can or cannot do to construct meaning. Teachers also use ongoing assessments—such as running records, individual conferences, and observations of students' reading—to monitor and support student progress.

Both of these approaches to helping readers select books appropriate to their reading levels—readability formulas and reading levels—are subjective and prone to misinterpretation. What is needed is one scale that can describe the reading demands of a piece of text and the reading ability of a child. The Lexile Framework for Reading is a powerful tool for determining the reading ability of children *and* finding texts that provide the appropriate level of challenge.

Jack Stenner, a leading psychometrician and one of the developers of the Lexile Framework, likens this situation to an experience he had when his son was young.

> Some time ago I went into a shoe store and asked for a fifth-grade shoe. The clerk looked at me suspiciously and asked if I knew how much shoe sizes varied among eleven-year-olds. Furthermore, he pointed out that shoe size was not nearly as important as purpose, style, color, and so on. But if I would specify the features I wanted and the size, he could walk to the back and quickly reappear with several options to my liking. The clerk further noted, somewhat condescendingly, that the store used the same metric to measure feet and shoes, and when there was a match between foot and shoe, the shoes got worn, there was no pain, and the customer was happy and became a repeat customer. I called home and got my son's shoe size and then asked the clerk for a "size-8-red-hightop-Penny Hardaway basketball shoe." After a brief transaction, I had the shoes.
>
> I then walked next door to my favorite bookstore and asked for a fifth-grade fantasy novel. Without hesitation, the clerk led me to a shelf where she gave me three choices. I selected one and went home with *The Hobbit*, a classic that I had read three times myself as a youngster. I later learned my son had yet to achieve the reading fluency needed to enjoy *The Hobbit*. His understandable response to my gifts was to put the book down in favor of passionately practicing free throws in the driveway.

The next section of this technical report describes the development and validation of the Lexile Framework for Reading.

The Lexile Framework for Reading

A reader's comprehension of text depends on several factors: the purpose for reading, the ability of the reader, and the text being read. Three common purposes for reading a text include reading for entertainment (literary experience), to gain information, or to perform a task. The reader brings to the reading experience a variety of important factors: reading ability, prior knowledge, interest level, and developmental appropriateness. For any text, three factors determine readability: complexity, support, and quality. All of these factors are important to consider when evaluating the appropriateness of a text for a reader. The Lexile Framework focuses primarily on two: reader ability and text complexity.

Like other readability formulas, the Lexile Framework examines two features of text to determine its complexity—semantic difficulty and syntactic complexity. Within the Lexile Framework, text complexity is determined by examining the characteristics of word frequency and sentence length. Text measures typically range from 200L to 1600L, but they can go below zero (reported as "Beginning Reader") and above 1800L. Within any one classroom, the reading materials will span a range of difficulty levels.

All symbol systems share two features: a semantic component and a syntactic component. In language, the semantic units are words. Words are organized according to rules of syntax into thought units and sentences (Carver, 1974). In all cases, the semantic units vary in familiarity and the syntactic structures vary in complexity. The comprehensibility, or difficulty, of a message is dominated by the familiarity of the semantic units and by the complexity of the syntactic structures used in constructing the message.

The Semantic Component. Most operationalizations of semantic difficulty are proxies for the probability that an individual will encounter a word in a familiar context and thus be able to infer its meaning (Bormuth, 1966). This is the basis of exposure theory, which explains the way receptive, or hearing, vocabulary develops (Miller & Gildea, 1987; Stenner, Smith, & Burdick, 1983). Klare (1963) hypothesized that the semantic component varied along a familiar-to-rare continuum. This concept was further developed by Carroll, Davies, and Richman (1971), whose word-frequency study examined the reoccurrence of words in a five-million-word corpus of running text. Knowing the frequency of words as they are used in written and oral communication provided the best means of inferring the likelihood that a word would be encountered by a reader and thus become part of that individual's receptive vocabulary.

Variables such as the average number of letters or syllables per word have been observed to be proxies for word frequency. There is a high negative correlation between the length of a word and the frequency of its usage. Polysyllabic words are used less frequently than monosyllabic words, making word length a good proxy for the likelihood that an individual will be exposed to a word.

In a study examining receptive vocabulary, Stenner, Smith, and Burdick (1983) analyzed more than 50 semantic variables in order to identify those elements that contributed to the difficulty of the 350 vocabulary items on Forms L and M of the *Peabody Picture Vocabulary Test*—Revised (Dunn & Dunn, 1981). Variables included part of speech, number of letters, number of syllables, the modal grade at which the word appeared in school materials, content classification of the word, the frequency of the word from two different word counts, and various algebraic transformations of these measures.

The word-frequency measure used was the raw count of how often a given word appeared in a corpus of 5,088,721 words sampled from a broad range of school materials (Carroll, Davies, & Richman, 1971). A "word family" included: (1) the stimulus word; (2) all plurals (adding *–s* or changing *–y* to *–ies*); (3) adverbial forms; (4) comparatives and superlatives; (5) verb forms (*–s, –d, –ed*, and *–ing*); (6) past participles; and (7) adjective forms. Correlations were computed between algebraic transformations of these means and the rank order of the test items. Since the items were ordered according to increasing difficulty, the rank order was used as the observed item difficulty. The mean log word frequency provided the highest correlation with item rank order ($r = -0.779$) for the items on the combined form.

The Lexile Framework currently employs a 600-million-word corpus when examining the semantic component of text. This corpus was assembled from the thousands of texts publishers measured between 1998 and 2002. When text is analyzed by MetaMetrics, all electronic files are initially edited according to established guidelines used with the Lexile Analyzer software. These guidelines include the removal of all incomplete sentences, chapter titles, and paragraph headings; running of a spell check; and repunctuating where necessary to correspond to how the book would be read by a child (for example, at the end of a page). The text is then submitted to the Lexile Analyzer, which examines the lengths of the sentences and the frequencies of the words and reports a Lexile measure for the book. When enough additional texts have been analyzed to make an adjustment to the corpus necessary and desirable, a linking study will be conducted to adjust the calibration equation such that the Lexile measure of a text based on the current corpus will be equivalent to the Lexile measure based on the new corpus.

The Syntactic Component. Klare (1963) provided a possible interpretation for how sentence length works in predicting passage difficulty. He speculated that the syntactic component varied with the load placed on short-term memory. Crain and Shankweiler (1988), Shankweiler and Crain (1986), and Liberman, Mann, Shankweiler, and Westelman (1982) have also supported this explanation. The work of these individuals has provided evidence that sentence length is a good proxy for the demand that structural complexity places upon verbal short-term memory.

While sentence length has been shown to be a powerful proxy for the syntactic complexity of a passage, an important caveat is that sentence length is not the underlying causal influence (Chall, 1988). Researchers sometimes incorrectly assume that manipulation of sentence length will have a predictable effect on passage difficulty. Davidson and Kantor (1982), for example, illustrated rather clearly that sentence length can be reduced and difficulty increased, and vice versa.

Based on previous research, it was decided to use sentence length as a proxy for the syntactic component of reading complexity in the Lexile Framework.

Calibration of Text Difficulty. A research study on semantic units conducted by Stenner, Smith, and Burdick (1983) was extended to examine the relationship of word frequency and sentence length to reading comprehension. In 1987(a), Stenner, Smith, Horiban, and Smith performed exploratory regression analyses to test the explanatory power of these variables. This analysis involved calculating the mean word frequency and the log of the mean sentence length for each of the 66 reading comprehension passages on the *Peabody Individual Achievement Test*. The observed difficulty of each passage was the mean difficulty of the items associated with the passage (provided by the publisher) converted to the logit scale. A regression analysis based on the word-frequency and sentence-length measures produced a regression equation that explained most of the variance found in the set of reading comprehension tasks. The resulting correlation between the observed logit difficulties and the theoretical calibrations was 0.97 after correction for range restriction and measurement error. The regression equation was further refined based on its use in predicting the observed difficulty of the reading comprehension passages on eight other standardized tests. The resulting correlation between the observed logit difficulties and the theoretical calibrations when the nine tests were combined into one was 0.93 after correction for range restriction and measurement error.

Once a regression equation was established linking the syntactic and semantic features of a text to its difficulty, that equation was used to calibrate test items and text.

The Lexile Scale. In developing the Lexile scale, the Rasch item-response theory model (Wright & Stone, 1979) was used to estimate the difficulties of items and the abilities of readers on the logit scale.

The calibrations of the items from the Rasch model are objective in the sense that the relative difficulties of the items will remain the same across different samples of readers (i.e., specific objectivity). When two items are administered to the same person, which item is harder and which one is easier can be determined. This ordering is likely to hold when the same two items are administered to a second person. If two different items are administered to the second person, there is no way to know which set of items is harder and which set is easier. The problem is that the location of the scale is not known. General objectivity requires that scores obtained from different test administrations be tied to a common zero—absolute location must be sample independent (Stenner, 1990). To achieve general objectivity, the theoretical logit difficulties must be transformed to a scale where the ambiguity regarding the location of zero is resolved.

The first step in developing a scale with a fixed zero was to identify two anchor points for the scale. The following criteria were used to select the two anchor points: they should be intuitive, easily reproduced, and widely recognized. For example, with most thermometers the anchor points are the freezing and boiling points of water. For the Lexile scale, the anchor points are text from seven basal primers for the low end and text from *The Electronic Encyclopedia* (Grolier, Inc., 1986) for the high end. These points correspond to medium-difficulty first-grade text and medium-difficulty workplace text.

The next step was to determine the unit size for the scale. For the Celsius thermometer, the unit size (a degree) is 1/100th of the difference between freezing (0 degrees) and boiling (100 degrees) water. For the Lexile scale, the unit size was defined as 1/1,000th of the difference between the mean difficulty of the primer material and the mean difficulty of the encyclopedia samples. Therefore, a Lexile by definition equals 1/1,000th of the difference between the comprehensibility of the primers and the comprehensibility of the encyclopedia.

The third step was to assign a value to the lower anchor point. The low-end anchor on the Lexile scale was assigned a value of 200.

Finally, a linear equation of the form

$$[(\text{Logit} + \text{constant}) \times \text{CF}] + 200 = \text{Lexile text measure} \qquad \text{(Equation 1)}$$

was developed to convert logit difficulties to Lexile calibrations. The values of the conversion factor (CF) and the constant were determined by substituting in the anchor points and then solving the system of equations.

Validity of the Lexile Framework for Reading

Validity is the "extent to which a test measures what its authors or users claim it measures; specifically, test validity concerns the appropriateness of inferences that can be made on the basis of test results" (Salvia & Ysseldyke, 1998). The 1999 *Standards for Educational and Psychological Testing* (America Educational Research Association, American Psychological Association, & National Council on Measurement in Education) state that "validity refers to the degree to which evidence and theory support the interpretations of test scores entailed in the uses of tests" (p. 9). In other words, does the test measure what it is supposed to measure? For the Lexile Framework, which measures a skill, the most important aspect of validity that should be examined is construct validity. The construct validity of the Lexile Framework for Reading can be evaluated by examining how well Lexile measures relate to other measures of reading comprehension and text complexity.

Lexile Framework Linked to Other Measures of Reading Comprehension. The Lexile Framework for Reading has been linked with numerous standardized tests of reading comprehension. When assessment scales are linked, a common frame of reference can be used to interpret the test results. This frame of reference can be "used to convey additional normative information, test-content information, and information that is jointly normative and content-based. For many test uses, [this frame of reference] conveys information that is more crucial than the information conveyed by the primary score scale" (Petersen, Kolen, & Hoover, 1989, p. 222).

Table 1 presents the results from linking studies conducted with the Lexile Framework for Reading. For each of the tests listed, student reading comprehension scores can also be reported as Lexile measures. This dual reporting provides a rich, criterion-related frame of reference for interpreting the standardized test scores. When a student takes one of the standardized tests, in addition to receiving his norm-referenced test results, he can receive a reading list that is targeted to his specific reading level.

TABLE 1. Results from linking studies conducted with the Lexile Framework for Reading.

Standardized Test	Grades in Study	*N*	Correlation Between Test Score and Lexile Measure
Stanford Diagnostic Reading Test (Version 4)	4, 6, 8, 10	1,169	0.91
TerraNova (CTBS/5)	2, 4, 6, 8	2,713	0.92
Metropolitan Achievement Test (Eighth Edition)	2, 4, 6, 8, and 10	2,382	0.93
Gates-MacGinitie Reading Test (Version 4)	2, 4, 6, 8, and 10	4,644	0.92
Utah Core Assessments	3–6	1,551	0.73
Texas Assessment of Knowledge and Skills	3, 5, and 8	1,960	0.60 to 0.73*
The Iowa Tests (Iowa Tests of Basic Skills and Iowa Tests of Educational Development)	3, 5, 7, 9, and 11	4,666	0.88
Stanford Achievement Test (Tenth Edition)	2, 4, 6, 8, and 10	3,064	0.93
Oregon Knowledge and Skills	3, 5, 8, and 10	3,180	0.89
Mississippi Curriculum Test (MCT)	2, 4, 6, and 8	55,564	0.90
Georgia Criterion-Referenced Competency Test (CRCT)	1–8	7,045	0.72 to 0.88*
Wyoming Performance Assessment for Wyoming Students (PAWS)	3, 5, 7, and 11	16,363	0.91
Arizona Instrument to Measure Progress (AIMS)	3, 5, 7, and 10	3,871	0.89
South Carolina Palmetto Achievement Challenge Tests (PACT)	3–8	7,735	0.87 to 0.88*
Comprehensive Testing Program (CTP 4 – ERB)	2, 4, 6, and 8	15,559	0.83 to 0.88
Oklahoma Core Competency Tests (OCCT)	3–8	924	0.71 to 0.75*
TOEFL iBT	NA	10,691	0.63 to 0.67
TOEIC	NA	2,906	0.73 to 0.74
Kentucky Performance Rating for Educational Progress (K-PREP)	3–8	2,799	0.71 to 0.79*
North Carolina ACT	11	6,480	0.84

Standardized Test	Grades in Study	*N*	Correlation Between Test Score and Lexile Measure
North Carolina READY End-of-Grades/End-of-Course Tests (NC READY EOG/EOC)	3, 5, 7, 8, and E2	3,472 12,356	0.88 to 0.89

Notes: Results are based on final samples used with each linking study.
*Not vertically equated; separate linking equations were derived for each grade.

Lexile Framework and the Difficulty of Basal Readers. In a study conducted by Stenner, Smith, Horabin, and Smith (1987b), Lexile calibrations were obtained for units in 11 basal series. It was hypothesized that each basal series was sequenced by difficulty. So, for example, the latter portion of a third-grade reader is presumably more difficult than the first portion of the same book. Likewise, a fourth-grade reader is presumed to be more difficult than a third-grade reader. Observed difficulties for each unit in a basal series were estimated by the rank order of the unit in the series. Thus, the first unit in the first book of the first grade was assigned a rank order of one, and the last unit of the eighth-grade reader was assigned the highest rank-order number.

Correlations were computed between the rank order and the Lexile calibration of each unit in each series. After correction for range restriction and measurement error, the average disattenuated correlation between the Lexile calibration of text comprehensibility and the rank order of the basal units was 0.995 (see Table 2).

TABLE 2. Correlations between theory-based calibrations produced by the Lexile equation and rank order of unit in basal readers.

Basal Series	Number of Units	r_{OT}	R_{OT}	R'_{OT}
Ginn Rainbow Series (1985)	53	.93	.98	1.00
HBJ Eagle Series (1983)	70	.93	.98	1.00
Scott Foresman Focus Series (1985)	92	.84	.99	1.00
Riverside Reading Series (1986)	67	.87	.97	1.00
Houghton-Mifflin Reading Series (1983)	33	.88	.96	.99
Economy Reading Series (1986)	67	.86	.96	.99
Scott Foresman American Tradition (1987)	88	.85	.97	.99
HBJ Odyssey Series (1986)	38	.79	.97	.99
Holt Basic Reading Series (1986)	54	.87	.96	.98
Houghton-Mifflin Reading Series (1986)	46	.81	.95	.98
Open Court Headway Program (1985)	52	.54	.94	.97
Total/Means	**660**	**.839**	**.965**	**.995**

r_{OT} = raw correlation between observed difficulties (O) and theory-based calibrations (T)
R_{OT} = correlation between observed difficulties (O) and theory-based calibrations (T) corrected for range restriction
R'_{OT} = correlation between observed difficulties (O) and theory-based calibrations (T) corrected for range restriction and measurement error
Mean correlations are the weighted averages of the respective correlations.

Based on the consistency of the results in Table 2, the Lexile Theory was able to account for the unit rank ordering of the 11 basal series despite numerous differences among them—prose selections, developmental range addressed, types of prose introduced (e.g., narrative versus expository), and purported skills and objectives emphasized.

Lexile Framework and the Difficulty of Reading Test Items. In a study conducted by Stenner, Smith, Horabin, and Smith (1987a), 1,780 reading comprehension test items appearing on nine nationally normed tests were analyzed. The study correlated empirical item difficulties provided by the publisher with the Lexile calibrations specified by computer analysis of the text of each item. The empirical difficulties were obtained in one of three ways. Three of the tests included observed logit difficulties from either a Rasch or three-parameter analysis (e.g., NAEP). For four of the tests, logit difficulties were estimated from item *p*-values and raw score means and standard deviations (Poznansky, 1990; Wright & Linacre, 1994). Two of the tests provided no item parameters, but in each case items were ordered on the test in terms of difficulty (e.g., PIAT). For these two tests, the empirical difficulties were approximated by the difficulty rank order of the items. In those cases where multiple questions were asked about a single passage, empirical item difficulties were averaged to yield a single observed difficulty for the passage.

Once theory-specified calibrations and empirical item difficulties were computed, the two arrays were correlated and plotted separately for each test. The plots were checked for unusual residual distributions and curvature, and it was discovered that the equation did not fit poetry items and noncontinuous prose items (e.g., recipes, menus, and shopping lists). This indicated that the universe to which the Lexile equation could be generalized was limited to continuous prose. The poetry and noncontinuous prose items were removed and correlations were recalculated. Table 3 contains the results of this analysis.

TABLE 3. Correlations between theory-based calibrations produced by the Lexile equation and the empirical item difficulty.

Test	Number of Questions	Number of Passages	Mean	SD	Range	Min	Max	r_{OT}	R_{OT}	R'_{OT}
SRA	235	46	644	353	1303	33	1336	.95	.97	1.00
CAT-E	418	74	789	258	1339	212	1551	.91	.95	.98
Lexile	262	262	771	463	1910	–304	1606	.93	.95	.97
PIAT	66	66	939	451	1515	242	1757	.93	.94	.97
CAT-C	253	43	744	238	810	314	1124	.83	.93	.96
CTBS	246	50	703	271	1133	173	1306	.74	.92	.95
NAEP	189	70	833	263	1162	169	1331	.65	.92	.94
Battery	26	26	491	560	2186	–702	1484	.88	.84	.87
Mastery	85	85	593	488	2135	–586	1549	.74	.75	.77
Totals/ Means	**1,780**	**722**	**767**	**343**	**1441**	**50**	**1491**	**.84**	**.91**	**.93**

r_{OT} = raw correlation between observed difficulties (O) and theory-based calibrations (T)
R_{OT} = correlation between observed difficulties (O) and theory-based calibrations (T) corrected for range restriction
R'_{OT} = correlation between observed difficulties (O) and theory-based calibrations (T) corrected for range restriction and measurement error
Means are computed on Fisher Ƶ transformed correlations.

The last three columns in Table 3 show the raw correlations between observed (O) item difficulties and theoretical (T) item calibrations, with the correlations corrected for restriction in range and measurement error. The Fisher Ƶ mean of the raw correlations (r_{OT}) is 0.84. When corrections are made for range restriction and measurement error, the Fisher Ƶ mean disattenuated correlation between theory-based calibration and empirical difficulty in an unrestricted group of reading comprehension items (R'_{OT}) is 0.93.

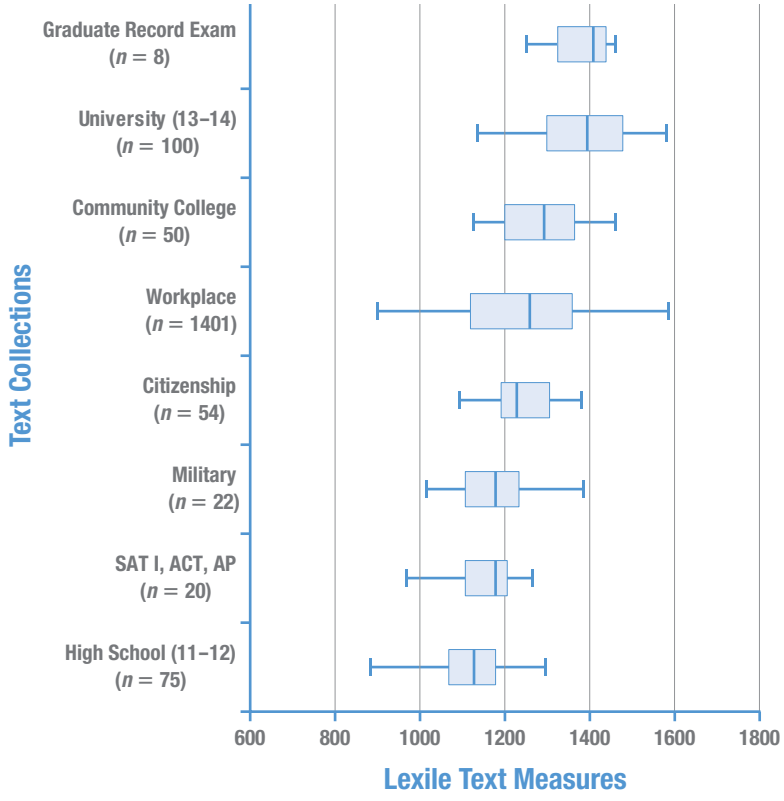
These results show that most attempts to measure reading comprehension—no matter what the item form, type of skill objectives assessed, or response requirement used—measure a common comprehension factor specified by the Lexile Theory.

College and Career Readiness and Text Complexity

There is increasing recognition of the importance of bridging the gap that exists between kindergarten and Grade 12 and higher education and other postsecondary endeavors. Many state and policy leaders have formed task forces and policy committees, such as P-20 councils.

In the article "A Text Readability Continuum for Postsecondary Readiness," in the *Journal of Advanced Academics* (2008), Williamson investigated the gap between high school textbooks and various reading materials across several postsecondary domains. As can be seen in Figure 2, the resources Williamson used were organized into four domains that correspond to the three major postsecondary endeavors that students can choose—further education, the workplace, or the military—and the broad area of citizenship, which cuts across all postsecondary endeavors. Williamson discovered a substantial increase in reading expectations and text complexity from high school to postsecondary domains—a gap large enough to help account for high remediation rates and disheartening graduation statistics (Smith, 2011).

FIGURE 2. A continuum of text difficulty for the transition from high school to postsecondary experiences (box plot percentiles: 5th, 25th, 50th, 75th, and 95th).[1]



1 Reprinted from Williamson, G. L. (2008). A text readability continuum for postsecondary readiness. *Journal of Advanced Academics, 19*(4), 602–632. Used by permission of SAGE Publication. All rights reserved.

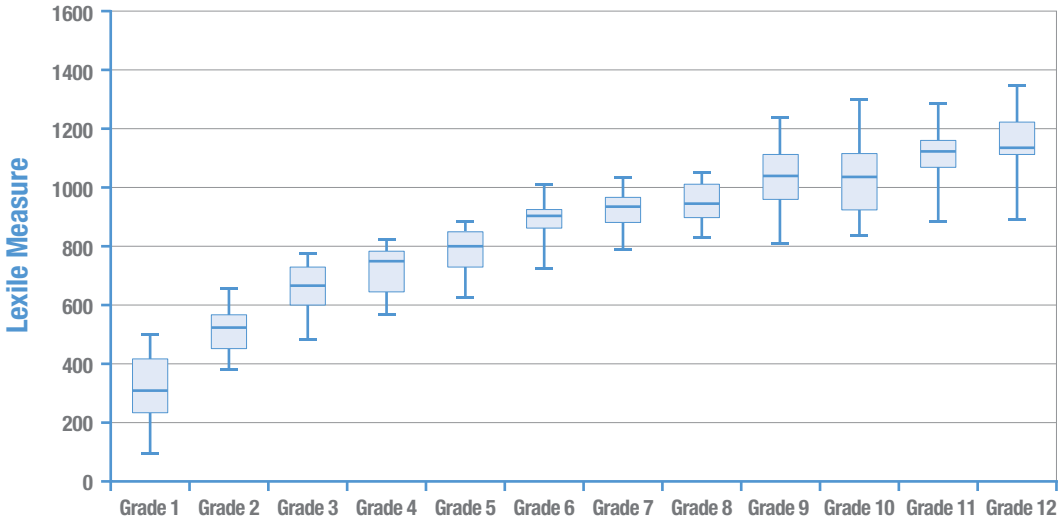
Expanding on Williamson's work, Stenner, Sanford-Moore, and Williamson (2012) aggregated the readability information across the various postsecondary options available to a high school graduate to arrive at a standard of reading needed by individuals to be considered "college and career ready." In their study, they included additional citizenship materials beyond those examined by Williamson (e.g., national and international newspapers and other adult reading materials, such as Wikipedia articles). Using a weighted mean of the medians for each of the postsecondary options (education, military, workplace, and citizenship), a measure of 1300L was defined as the general reading demand for postsecondary options and could be used to judge a student's "college and career readiness."

In Texas, two studies were conducted to examine the reading demands in various postsecondary options—technical college, community college, and four-year university programs. Under Commissioner Raymond Paredes, Texas Higher Education Coordinating Board (THECB) conducted a research study in 2007 (extended in 2008) that addressed the focal question, "How well does a student need to read to be successful in community colleges, technical colleges, and universities in Texas?" THECB staff collected a sample of books that first-year students in Texas would be likely to read in each setting. These books were measured in terms of their text complexity using the Lexile Framework for Reading. Because the TAKS had already been linked with Lexile measures for several years, the THECB study was able to overlay the TAKS cut scores onto the post-high school reading requirements.

Since the THECB study was completed, other states have followed the Texas example and used the same approach in examining the gap from high school to the postsecondary world. In 2009, a similar study was conducted for the Georgia Department of Education; in 2010, a study was conducted for the Tennessee Department of Education. In terms of mean text demand, the results across the three states produced similar estimates of the reading ability needed in higher-education institutions: Texas, 1230L; Georgia, 1220L; and Tennessee, 1260L. When these results are incorporated with the reading demands of other postsecondary endeavors (military, citizenship, workplace) and adult reading materials (national and international newspapers, Wikipedia articles) used by Stenner, Koons, and Swartz (2010), the college and career readiness standard for reading is 1293L. These results are based on more than 105,000,000 words from approximately 3,100 sources in the adult text space.

Between 2004 and 2008, MetaMetrics (Williamson, Koons, Sandvik, & Sanford-Moore, 2012) collected and measured textbooks across the K–12 educational continuum. The box-and-whisker plot in Figure 3 shows the Lexile measures (*y*-axis) across grades as defined in the United States. For each grade, the box refers to the interquartile range. The line within the box indicates the median. The end of each whisker shows the 5th- and 95th-percentile text complexity measures in the Lexile metric for each grade. This information can provide a basis for defining at what level students need to be able to read to be ready for various postsecondary endeavors, such as further education beyond high school and entering the workforce.

FIGURE 3. Text complexity distributions, in Lexile units, by grade (whiskers represent 5th and 95th percentiles).[2]



The question for educators becomes how to determine if a student is "on track" for college and career as previously defined in the Common Core State Standards and described above. "As state departments of education, and the districts and schools within those respective states, transition from *adopting* the new Common Core State Standards to the more difficult task of *implementing* them, the challenge now becomes how to translate these higher standards into tangible, practical, and cost-effective curricula" (Smith, 2012). Implementing the Common Core State Standards will require districts and schools to develop new instructional strategies and complementary resources that are not only aligned with these national college- and career-readiness standards but also utilize and incorporate proven and cost-effective tools that are universally accessible to all stakeholders.

The Standards for English Language Arts focus on the importance of text complexity. As stated in Standard 10, students must be able to "read and comprehend complex literary and informational texts independently and proficiently" (Common Core State Standards for English Language Arts, College and Career Readiness Anchor Standards for Reading, NGA Center & CCSSO, 2010a, p. 10).

The Common Core State Standards recommends a three-part model for evaluating the complexity of a text that takes into account its qualitative dimensions, quantitative measure, and reader and task considerations. It describes text complexity as "the inherent difficulty of reading and comprehending a text combined with consideration of reader and task variables . . . a three-part assessment of text [complexity] that pairs qualitative and quantitative measures with reader-task considerations" (NGA Center & CCSSO, 2010b, p. 43). In simpler terms, *text complexity is a transaction between text, reader, and task*. The quantitative aspect of defining text complexity consists of a stair-step progression of increasingly difficult text by grade levels (Common Core State Standards for English Language Arts, Appendix A, NGA Center & CCSSO, 2010, p. 8). This continuum can be "stretched" to describe the reading demands expected of students in Grades 1–12 who are "on track" for college and career (Sanford-Moore & Williamson, 2012).

2 Reprinted from Williamson, G. L., Koons, H., Sandvik, T., & Sanford-Moore, E. (2012). The text complexity continuum in grades 1–12 (MetaMetrics Research Brief): Durham, NC: MetaMetrics, Inc. Used by permission of MetaMetrics, Inc. All rights reserved.

TABLE 4. Lexile ranges aligned to college- and career-readiness expectations, by grade.

Grade	2012 "Stretch" Text Measure
1	190L to 530L
2	420L to 650L
3	520L to 820L
4	740L to 940L
5	830L to 1010L
6	925L to 1070L
7	970L to 1120L
8	1010L to 1185L
9	1050L to 1260L
10	1080L to 1335L
11–12	1185L to 1385L

Lexile Item Bank

The Lexile Item Bank contains over 10,000 items that were developed between 1986 and 2013 for research purposes with the Lexile Framework. Over half of these items are included in the Reading Comprehension Assessment subtest of the *Reading Inventory*.

Passage Selection. The majority of passages selected for use came from "real world" reading materials that students may encounter both in and out of the classroom. Sources include textbooks, literature, and periodicals from a variety of interest areas and material written by authors of different backgrounds. The following criteria were used to select passages:

- The passage must develop one main idea or contain one complete piece of information.
- Understanding of the passage is independent of the information that comes before or after the passage in the source text.
- Understanding of the passage is independent of prior knowledge not contained in the passage.

With the aid of a computer program, item writers examined blocks of text (minimum of three sentences) that were calibrated to be within 100L of the source text. From these blocks of text, item writers were asked to select four to five that could be developed as items. If it was necessary to shorten or lengthen the passage in order to meet the criteria for passage selection, the item writer could immediately recalibrate the text to ensure that it was still targeted within 100L of the complete text (i.e., source targeting).

Item Format. The native-Lexile item format is an embedded completion format. The embedded completion format is similar to the fill-in-the-blank format. When properly written, this format directly assesses the reader's ability to draw inferences and establish logical connections between the ideas in the passage. The reader is presented with a passage of approximately 30 to 150 words in length. The passages are shorter for beginning readers and longer for more advanced readers. The passage is then response illustrated—a statement with a word or phrase missing is added at the end of the passage, followed by four options. From the four presented options, the reader is asked to select the option that "best" completes the statement. With this format, all options are semantically and syntactically appropriate completions of the sentence, but one option is unambiguously the "best" option when considered in the context of the passage.

The statement portion of the embedded completion item can assess a variety of skills related to reading comprehension: the ability to paraphrase information in the passage, draw a logical conclusion based on information in the passage, make an inference, identify a supporting detail, or make a generalization based on information in the passage. The statement is written to ensure that by reading and comprehending the passage, the reader is able to select the correct option. When the embedded completion statement is read by itself, each of the four options is plausible.

Item-Writer Training. Items were written and/or reviewed by educators who had experience with the everyday reading ability of students at various levels. The use of individuals with these types of experiences helped to ensure that the items are valid measures of reading comprehension. Item writers were provided with training materials concerning the embedded completion item format and guidelines for selecting passages, developing statements, and creating options. The item-writing materials also contained incorrect items that illustrated the criteria used to evaluate items and corrections based on those criteria. The final phase of item-writer training was a short practice session with three items.

Item writers were provided vocabulary lists to use during statement and option development. The vocabulary lists were compiled from spelling books one grade level below the level targeted by the item. The rationale was that these words should be part of a reader's "working" vocabulary if they were learned the previous year.

Item writers were also given extensive training related to sensitivity issues. Part of the item-writing materials addressed these issues and identified areas to avoid when selecting passages and developing items. The following areas were covered: violence and crime, depressing situations/death, offensive language, drugs/alcohol/tobacco, sex/attraction, race/ethnicity, class, gender, religion, the supernatural/magic, parent/family, politics, animals/environment, and brand names/junk food. These materials were developed to be compliant with standards of universal design and fair access—equal treatment of the sexes, fair representation of minority groups, and the fair representation of disabled individuals.

Item Review. All items were subjected to a two-stage review process. First, items were reviewed and edited according to the criteria identified in the item-writing materials and for sensitivity issues. Approximately 25% of the items developed were deleted for various reasons. Where possible, items were edited and maintained in the item bank.

Items were then reviewed and edited by a group of specialists representing various perspectives: test developers, editors, and curriculum specialists. These individuals examined each item for sensitivity issues and the quality of the response options. During the second stage of the item review process, items were either "approved as presented," "approved with edits," or "deleted." Approximately 10% of the items written were "approved with edits" or "deleted" at this stage. When necessary, item writers received additional ongoing feedback and training.

Item Analyses. As part of the linking studies and research studies conducted by MetaMetrics, items in the Lexile Item Bank were evaluated for difficulty (relationship between logit [observed Lexile measure] and theoretical Lexile measure), internal consistency (point-biserial correlation), and bias (ethnicity and gender where possible). Where necessary, items were deleted from the item bank or revised and recalibrated.

During Spring 1999, eight levels of a Lexile assessment were administered in a large urban school district to students in Grades 1–12. The eight test levels were administered in Grades 1, 2, 3, 4, 5, 6, 7–8, and 9–12 and ranged from 40 to 70 items depending on the grade level. A total of 427 items were administered across the eight test levels. Each item was answered by at least 9,000 students (the number of students per level ranged from 9,286 in Grade 2 to 19,056 in Grades 9–12). The item responses were submitted to a Winsteps IRT analysis. The resulting item difficulties (in logits) were assigned Lexile measures by multiplying by 180 and anchoring each set of items to the mean theoretical difficulty of the items on the form.

Description of the *Reading Inventory*

Description of the Foundational Reading Assessment and Reading Comprehension Assessment Subtests of the *Reading Inventory*

Test Materials

The *Reading Inventory* is an interactive reading test that provides an assessment of reading ability. It consists of two subtests: the Foundational Reading Assessment and the Reading Comprehension Assessment.

The Foundational Reading Assessment reports student performance in accuracy and fluency scores that indicate whether a student's foundational reading skills are below basic, basic, or proficient. Success on the Foundational Reading Assessment indicates readiness to take the Reading Comprehension Assessment.

The Reading Comprehension Assessment reports student performance in Lexile measures. The results from the Reading Comprehension Assessment can be used to measure how well readers comprehend literary and expository texts of varying difficulties, and whether students are on track to college and career readiness.

Item Bank. The two subtests of the *Reading Inventory* consist of item types that assess different aspects of reading ability. The item types of the Foundational Reading Assessment are discussed here. These items assess foundational reading skills.

The Foundational Reading Assessment

The Foundational Reading Assessment includes a total of 82 possible items, divided into three strands: Phonological Awareness, Letter-Word Identification, and Word Attack.

- The Phonological Awareness Strand includes 12 total items, specifically three items designed to measure students' rhyme identification skills and nine items designed to measure students' ability to identify initial, final, and medial sounds.
- The Letter-Word Identification Strand includes 30 total items, specifically 10 items designed to measure students' knowledge of uppercase and lowercase letter names and 20 items designed to measure students' sight word knowledge.
- The Word Attack Strand includes 40 total items, specifically 10 items designed to measure students' ability to identify letter sounds and 30 nonword items designed to measure students' decoding skills.

Item Bank. The two subtests of the *Reading Inventory* consist of item types that assess different aspects of reading ability. The item types of the Reading Comprehension Assessment are discussed here. These items assess reading comprehension.

The Reading Comprehension Assessment

The Reading Comprehension Assessment consists of a bank of over 5,000 multiple-choice items that monitor reading comprehension. The items are presented as embedded completion items. In this question format the student is asked to read a passage and then choose the option that best fills the blank in the last statement. In order to complete the statement, the student must respond on a literal level (recall a fact) or an inferential level (determine the main idea of the passage, draw an inference from the material presented, or make a connection between sentences in the passage).

Reading Inventory Professional Learning Guide. This guide provides an overview of the *Reading Inventory* software and software support. Educators are provided information on getting started with the software (installing it, enrolling students, reporting results), how the *Reading Inventory* student program works, and working with the Student Achievement Manager (SAM). SAM is the learning management system for all Houghton Mifflin Harcourt software programs including *READ 180*, *System 44, Reading Counts!, Phonics Inventory,* and *Reading Inventory*. Educators use SAM to collect and organize student-produced data. SAM helps educators understand and implement data-driven instruction by:

- Managing student rosters
- Generating reports that capture student performance data at various levels of aggregation (student, classroom, group, school, and district)
- Locating helpful resources for classroom instruction and aligning the instruction to standards
- Communicating student progress to parents, teachers, and administrators

The *Reading Inventory Professional Learning Guide* also provides teachers with information on how to use the results from the *Reading Inventory* in the classroom. Teachers can access their students' reading levels and prescribe appropriate instructional support material to aid in developing their students' reading skills and growth as readers. Information related to best practices for test administration, interpreting reports, and using Lexile measures in the classroom is provided. Reproducibles are also provided to help educators communicate *Reading Inventory* results to parents, monitor growth, and recommend books.

Test Administration and Scoring

Administration Time. The *Reading Inventory* can be administered at any time during the school year. It is administered individually via a computer or iPad. The test is intended to be untimed. Typically, students take approximately 20 minutes to complete the Foundational Reading Assessment and 20–30 minutes to complete the Reading Comprehension Assessment. There should be at least eight weeks of elapsed time between administrations to allow for growth in reading ability.

Administration Setting. The *Reading Inventory* can be administered in a group setting or individually—wherever computers or iPads are available. The setting should be quiet and free from distractions. Teachers should make sure that students have the computer skills needed to complete the test. Practice items are provided to ensure that students understand the directions and know how to use the computer to take the test.

The Foundational Reading Assessment: Administration and Scoring

The student experience with the Foundational Reading Assessment consists of two parts: Mouse Skills Practice Task and Foundational Reading Assessment. The assessment consists of three strands—Phonological Awareness, Letter-Word Identification, and Word Attack—and reports a total accuracy score and a total fluency score.

The scoring system was designed to assess fluency, which refers to the combination of accurate and efficient or speedy responding. A fluent response must be accurate as well as sufficiently fast. To get credit for a fluent response to an item, the response has to be correct and the total response time (latency) cannot exceed the threshold time.

There are a number of advantages to this kind of scoring. First, this method of scoring produces "hybrid" scores that combine accuracy and speed of responding. Hybrid scores have proven to be effective on other reading measures such as the Test of Word Reading Efficiency, Second Edition (TOWRE-2) (Torgesen, Wagner, & Rashotte, 2012) and the Test of Silent Reading Efficiency and Comprehension (TOSREC) (Wagner, Torgesen, Rashotte, & Pearson, 2010). One reason that hybrid scores are effective is that individual and developmental differences in underlying reading skill affect both accuracy and speed of response. Therefore, a score that incorporates both speed and accuracy is better than one that is based on only speed or accuracy.

A second advantage of this method of scoring is that outlying response times are handled implicitly. If performance on an assessment is measured in terms of average response time, a practical problem that must be dealt with is what to do about outlying response times. For example, an outlying response time of 20 seconds will have a large impact on the average response time for a set of responses that typically fall in the range of 1 to 2 seconds. The scoring method used on the Foundational Reading Assessment handles this potential problem in that a response that exceeds the threshold value gets an item fluency score of 0 regardless of how slow it is.

A third advantage of this method of scoring is that it handles a practical problem that arises in the Foundational Reading Assessment. Because the cursor must be moved to select the correct response in a list of distractors, the amount of cursor movement required varies across items depending on the position of the target item in the list of distractors. This presumably affects response times. This potential unwanted source of variability is handled implicitly by the fact that item thresholds are determined empirically for each individual item. Differences in response time associated with differences in amount of cursor movement required are reflected in the empirical distribution of response times that are the basis of the analyses used to identify the optimal item threshold.

A final advantage of this method of scoring is that it facilitates maximal use of the information gained from responses to all items, ranging from easier sight word items to more difficult nonword items. When only accuracy of responses is considered, ceiling effects can be common for easy items (e. g., cat) with nearly all children getting the item correct. But by considering fluency, thereby requiring that the response be made prior to the item threshold response time, the ceiling effect on accuracy can be minimized and the item becomes more informative about a child's level of performance.

The Reading Comprehension Assessment: Administration and Scoring

The student experience with the Reading Comprehension Assessment consists of three parts: Practice Test, Locator Test, and Reading Comprehension Assessment. Prior to testing, the teacher or administrator inputs information into the computer-adaptive algorithm that controls the administration of the test. The student's identification number and grade level must be input; prior standardized reading results (Lexile measure, percentile, stanine, or NCE) and the teacher's judgment of the student's reading level (Far Below, Below, On, Above, or Far Above) may also be input. This information is used to determine the best starting point for the student.

The Practice Test consists of three items that are significantly below the student's reading level (approximately 10th percentile for grade level). The practice items are administered only during the student's first experience with the Reading Comprehension Assessment and are designed to ensure that the student understands the directions and how to use the computer to take the test.

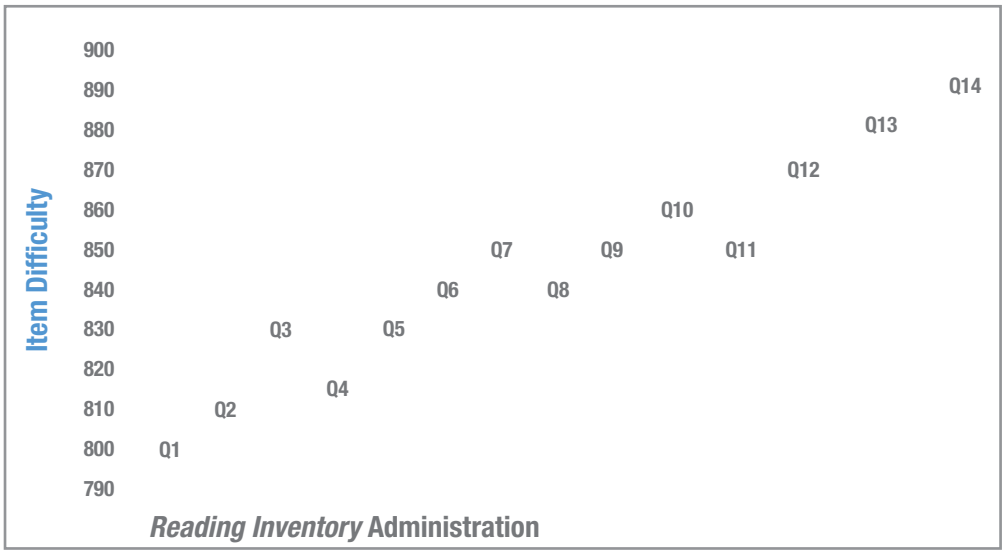
For students in Grades 7 and above and for whom the only data to set the starting item difficulty is their grade level, a Locator Test is presented to better target the students. The Locator Test consists of two to five items that have a reading demand of 500L below the "On Level" designation for the grade. The results are used to establish an estimate of the student's prior reading ability level. If students respond incorrectly to one or more items, their prior reading ability is set to "Far Below Grade Level."

The Reading Comprehension Assessment uses a three-phase approach to assess a student's level of reading ability: Start, Step, Stop. During test administration, the computer adapts the test continually according to the student's responses to the items. The student *starts* the test; the test *steps* up or down according to the student's performance; and, when the computer has enough information about the student's reading level, the test *stops*.

The first phase, *Start*, determines the best point on the Lexile scale to begin testing the student. The more information that is input into the algorithm, the better targeted the beginning of the test will be. Research has shown that well-targeted tests include less error in reporting student scores than poorly targeted tests. A student is targeted in one of three ways: (1) the teacher or test administrator enters the student's Estimated Reading Level; (2) the student is in Grade 6 or below, and the student's grade level is used; or (3) the student is in Grade 7 or above, and the Locator Test is administered.

For the student whose test administration is illustrated in Figure 4, the teacher input the student's grade (6) and Lexile measure from the previously administered Reading Comprehension Assessment-Print.

FIGURE 4. Sample administration of the Reading Comprehension Assessment for a sixth-grade student with a prior Lexile measure of 880L.



The second phase, *Step*, controls the selection of items presented to the student. If only the student's grade level was input during the first phase, then the student is presented with an item at the 50th percentile for her grade. If more information about the student's reading ability was input during the first phase, then the student is presented with an item that is nearer to her "true" ability. If the student answers the item correctly, then she is presented with an item that is slightly more difficult. If the student responds incorrectly to the item, then she is presented with an item that is slightly easier. After the student responds to each item, her Reading Comprehension Assessment score is recomputed.

Figure 4 above shows how the Reading Comprehension Assessment could be administered. The first item presented to the student measured 800L. Because she answered the item correctly, the next item was slightly more difficult (810L). Her third item measured 830L. Because she responded incorrectly to this item, the next item was slightly easier (820L).

The final phase, *Stop*, controls the termination of the test. Each student will be presented 15–25 items. The exact number of items a student receives depends on how the student responds to the items as they are presented and how well the test is targeted in the beginning. Well-targeted tests begin with less measurement error, and, therefore, the student will be asked to respond to fewer items.

Because the test administered to the student in Figure 4 was well-targeted to her reading level (50th percentile for Grade 6 is 880L), only 15 items were administered to the student to determine her score.

Results from the Reading Comprehension Assessment are reported as scale scores (Lexile measures). This scale extends from Beginning Reader (less than 0L) to above 1600L. A scale score is determined by the difficulty of the items a student answered both correctly and incorrectly. Scale scores can be used to report the results of both criterion-referenced tests and norm-referenced tests.

There are many reasons to use scale scores rather than raw scores to report test results. Scale scores overcome the disadvantage of many other types of scores (e.g., percentiles and raw scores) in that equal differences between scale score points represent equal differences in achievement. Each question on a test has a unique level of difficulty; therefore, answering 23 items correctly on one administration of a test requires a slightly different level of achievement than answering 23 items correctly on another administration of the test. But receiving a scale score (in this case, a Lexile measure) of 675L on one administration of a test represents the same level of reading ability as receiving a scale score of 675L on another administration of the test.

Keep in mind that no one test should be the sole determinant when making high-stakes decisions about students (e.g., summer-school placement or retention). Consider the student's interests and experiences, as well as knowledge of the student's reading abilities, when making these kinds of decisions.

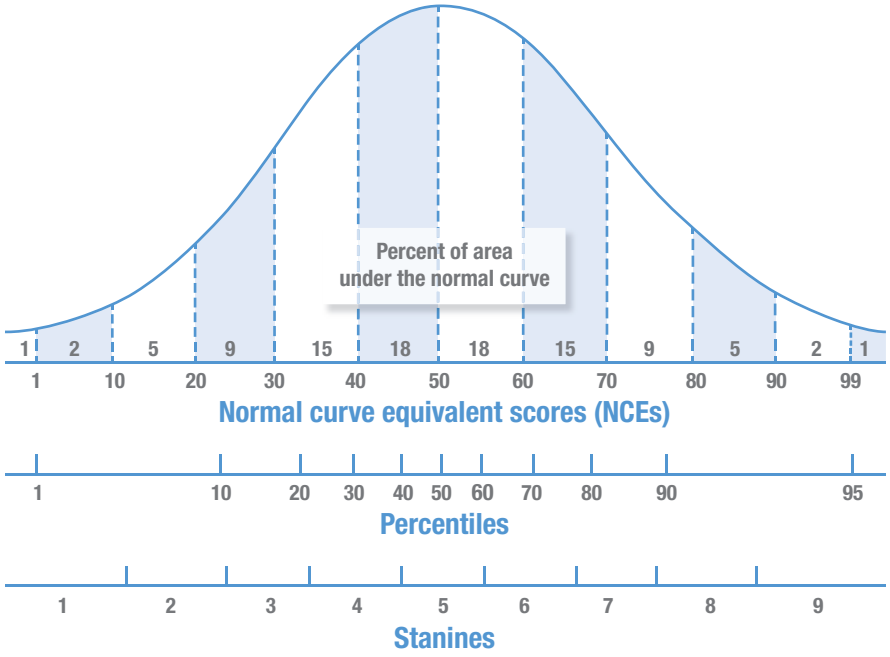
The Reading Comprehension Assessment begins with the concept of targeted level testing and takes it a step further. With the Lexile Framework as the yardstick of text complexity, the Reading Comprehension Assessment produces a measure that places texts and readers on the same scale. The Lexile measure connects each student to actual reading materials—school texts, story books, magazines, websites, newspapers, employee instructions—that can be readily understood by that student. Because the Reading Comprehension Assessment provides an accurate measure of where each student reads among the variety of reading materials calibrated by the Lexile Analyzer and found on the Lexile website (www.lexile.com/fab), the instructional approach and reading assignments for optimal growth are explicit. The Reading Comprehension Assessment's targeted testing not only measures how well students can actually read, but also locates them among the real reading materials that are most useful to them. In addition, the performance experience of taking a targeted test, a test that, because of its targeting, is both challenging and reassuring, brings out the best in students.

Interpreting *Reading Inventory* Scores

The *Reading Inventory* provides both criterion-referenced and norm-referenced interpretations. Criterion-referenced interpretations of test results provide a rich frame of reference that can be used to guide instruction and text selection for optimal student reading growth. While norm-referenced interpretations of test results are often required for accountability purposes, they indicate only how well the student is reading in relation to how similar students read.

Norm-Referenced Interpretations. A norm-referenced interpretation of a test score expresses how a student performed on the test compared to other students of the same age or grade. Norm-referenced interpretations of reading test results, however, do not provide any information about what a student can or cannot read. Percentiles, normal curve equivalents (NCEs), scale scores, and stanines are used to report test results when making comparisons (norm-referenced interpretations) for accountability purposes. For a comparison of these measures, refer to Figure 5.

FIGURE 5. Normal distribution of scores described in scale scores, percentiles, stanines, and normal curve equivalents (NCEs).



The *percentile rank* of a score indicates the percentage of scores less than or equal to that score. Percentile ranks range from 1 to 99. For example, if a student scores at the 65th percentile, it means that he or she performed as well as or better than 65% of the norm group. Real differences in performance are greater at the ends of the percentile range than in the middle. Percentile ranks of scores can be compared across two or more distributions; percentile ranks cannot be used to determine differences in relative rank due to the fact that the intervals between adjacent percentile ranks do not necessarily represent equal raw score intervals. *Note that the percentile rank does not refer to the percentage of items answered correctly.*

A *normal curve equivalent* (NCE) is a normalized student score with a mean of 50 and a standard deviation of 21.06. NCEs range from 1 to 99. NCEs allow comparisons between different tests for the same student or group of students and between different students on the same test. NCEs have many of the same characteristics as percentile ranks but have the additional advantage of being based on an interval scale. That is, the difference between two consecutive scores on the scale has the same meaning throughout the scale. NCEs are required by many categorical funding agencies (for example, Title I).

A *stanine* is a standardized student score with a mean of 5 and a standard deviation of 2. Stanines range from 1 to 9. In general, stanines of 1–3 are considered below average, stanines of 4–6 are considered average, and stanines of 7–9 are considered above average. A difference of 2 between the stanines for two measures indicates that the two measures are significantly different. Stanines, like percentiles, indicate a student's relative standing in a norm group.

Although not very useful at the student level, normative information can be useful (and is often required) at the aggregate levels for program evaluation.

The Foundational Reading Assessment

Students in Grades K–2 are provided a foundational fluency measure that can be reviewed against beginning, middle, and end-of-year grade level benchmarks in order to measure students' progress in foundational reading skills. Teachers can administer the Foundational Reading Assessment in the beginning, middle, and end of a school year to monitor student progress against the benchmarks. The benchmark skills that are assessed by the Foundational Reading Assessment are prerequisite skills for comprehending texts, and those foundational skills are typically developed during Grades K–2. A linking study was conducted with DIBELS Next (Dynamic Indicators of Basic Early Literacy Skills, Next) that allows for a student's fluency score on the Foundational Reading Assessment to be interpreted in relation to corresponding DIBELS Next national percentile scores. Participants in the Foundational Reading Assessment Development Study were also administered DIBELS Next. DIBELS Next produces a Composite Score and corresponding benchmark level (At or Above Benchmark, Below Benchmark, or Well Below Benchmark). DIBELS Next composite scores are associated with nationally normed percentile scores (Cummings, Kennedy, Otterstedt, Baker, & Kame'enui, 2011). Equipercentile equating was used to link the Foundational Reading Assessment fluency scores to DIBELS Next composite scores. Subsequently, the Foundational Reading Assessment scores were linked to the DIBELS Next percentile scores.

Linking the Foundational Reading Assessment fluency performance to DIBELS Next benchmark levels and percentile scores provides educators with insight as to whether a student's Foundational Reading Assessment fluency performance is consistent with his or her DIBELS Next performance. A Foundational Reading Assessment score that corresponds to a DIBELS Next benchmark level of At or Above indicates that the odds of a student achieving subsequent early literacy goals are from 80% to 90%, and the student is likely to continue to make sufficient progress through exposure to the core reading program. A Foundational Reading Assessment score that corresponds to a DIBELS Next benchmark level of Below indicates that the odds of a student achieving subsequent early literacy goals are from 40% to 60%, and the student is likely to need additional support beyond mere exposure to the student's regular reading program. A Foundational Reading Assessment score that corresponds to a DIBELS Next benchmark of Well Below indicates that the odds of a student achieving subsequent early literacy goals are from 10% to 20%, and the student is likely to continue to require intensive literacy support. See Table 5 for Foundational Reading Assessment total fluency scores and their corresponding DIBELS Next composite score percentiles.

TABLE 5. Foundational Reading Assessment total fluency scores and the corresponding DIBELS Next composite score percentiles.

FOUNDATIONAL READING ASSESSMENT TOTAL FLUENCY	DIBELS NEXT COMPOSITE SCORE PERCENTILES		
Score	Kindergarten	First Grade	Second Grade
0	1	1	1
1	2	1	1
2	3	1	1
3	4	1	1
4	5	1	1
5	6	2	1
6	7	2	1
7	9	2	1
8	13	2	2
9	14	2	2

FOUNDATIONAL READING ASSESSMENT TOTAL FLUENCY	DIBELS NEXT COMPOSITE SCORE PERCENTILES		
Score	Kindergarten	First Grade	Second Grade
10	20	2	2
11	24	3	2
12	29	3	2
13	35	4	2
14	41	4	2
15	46	5	2
16	51	5	2
17	53	6	2
18	58	6	2
19	59	7	2
20	63	8	2
21	68	11	2
22	72	14	2
23	75	15	2
24	79	17	3
25	82	18	3
26	84	19	3
27	87	20	3
28	89	21	3
29	89	24	3
30	90	28	3
31	91	30	4
32	92	32	4
33	93	37	4
34	94	40	5
35	95	42	5
36	95	46	5
37	96	48	5
38	96	55	6
39	97	57	6
40	97	60	6
41	97	61	6
42	97	65	6
43	97	68	7

FOUNDATIONAL READING ASSESSMENT TOTAL FLUENCY	DIBELS NEXT COMPOSITE SCORE PERCENTILES		
Score	Kindergarten	First Grade	Second Grade
44	98	71	7
45	98	74	7
46	98	75	7
47	98	78	7
48	99	79	8
49	99	80	8
50	>99	81	8
51	>99	82	8
52	>99	84	9
53	>99	86	10
54	>99	87	11
55	>99	89	16
56	>99	90	19
57	>99	91	23
58	>99	91	29
59	>99	91	34
60	>99	92	37
61	>99	92	42
62	>99	92	45
63	>99	93	51
64	>99	93	55
65	>99	94	59
66	>99	94	64
67	>99	95	67
68	>99	96	68
69	>99	96	72
70	>99	97	81
71	>99	98	84
72	>99	98	85
73	>99	98	87
74	>99	99	89
75	>99	99	93
76	>99	99	94
77	>99	99	95

FOUNDATIONAL READING ASSESSMENT TOTAL FLUENCY	DIBELS NEXT COMPOSITE SCORE PERCENTILES		
Score	**Kindergarten**	**First Grade**	**Second Grade**
78	>99	99	96
79	>99	99	97
80	>99	99	98
81	>99	99	99
82	>99	99	99

The Reading Comprehension Assessment

A linking study conducted by MetaMetrics with the Lexile Framework developed normative information based on a sample of 512,224 students from a medium-to-large state. The majority of the students in the norming population were White (66.3%), with 29.3% African American, 1.7% Native American, 1.2% Hispanic, 1.0% Asian, and 0.6% Other. Less than 1% (0.7%) of the students were classified as "limited English proficient," and 10.1% of the students were classified as "Students with Disabilities." Approximately 40% of the students were eligible for the free or reduced-price lunch program. Approximately half of the schools in the state had some form of Title I program (either school-wide or targeted assistance). The sample's distributions of scores on norm-referenced and other standardized measures of reading comprehension are similar to those reported for national distributions. Appendix B contains the Fall and Spring normative data for Grades 1–12 at select percentiles.

An important feature of the Lexile Framework is that it also provides criterion-referenced interpretations of every measure. A criterion-referenced interpretation of a test score compares the specific knowledge and skills measured by the test to the student's proficiency with the same knowledge and skills. Criterion-referenced scores have meaning in terms of what the student knows or can do, rather than in relation to the scores produced by some external reference (or norm) group. When a reader's measure is equal to the task's calibration, then the Lexile scale forecasts that the individual has a 75% comprehension rate on that task. When a number of 20 such tasks are given to this reader, one expects three-fourths of the responses to be correct. If the task is more difficult than the reader's measure, then the probability is less than 75% that the response of the person to the task will be correct. Similarly, when the task is easier than a reader's measure, then the probability is greater than 75% that the response will be correct.

Empirical evidence supports the choice of a 75% target comprehension rate, as opposed to, say, a 50% or a 90% rate. Research has shown that when students read text at their reading levels, they experience optimal reading comprehension for learning (Crawford, 1978; Guthrie & Davis, 2003; Jalongo, 2007). In addition, students who are better readers are also higher achievers and engage in life-long learning in relation to careers (Crawford, 1978; Kirsch, de Jong, LaFontaine, McQueen, Mendelovits, & Monseur, 2002). In a review of prior studies, Squires and his colleagues (1983) found 75% to be the optimal student success rate for learning. They noted that a reanalysis of the Fischer (Denham & Lieberman, 1980) data by Rim showed that reading achievement by Grade 2 students increased up to a 75% success rate and then began to decrease. A 75% success rate is also supported by the findings of Crawford, King, Brophy, and Evertson (1975), Rim (1980), and Huynh (1998).

O'Connor, Swanson, and Geraghty (2010) randomly assigned 123 students in Grades 2 and 4 to three different conditions for the difficulty level of reading materials: the grade-appropriate condition, the "difficult" condition, and a control group. Participants were assessed using a pretest to measure comprehension and fluency, then given a 20-week intervention course to evaluate comprehension growth over time based on passage difficulty level. Finally, a posttest was administered to determine growth differences between the groups. With respect to both the pretest

and posttest performance, the differences between level and comprehension were found to be significant, where performance was highest for the grade-appropriate condition and lowest for the "difficult" condition. The results also indicated that there were also significant gains over time for students reading material at their appropriate reading level. The research suggests that students should be given reading level materials that match their comprehension goals. It may be, however, that there is no one optimal rate of reading comprehension. It may be that there is a range in which individuals can operate to optimally improve their reading ability.

Similarly, research by O'Connor, Bell, Harty, Larkin, Sackor, and Zigmond (2002) investigated the role of text difficulty on reading ability for students who experienced difficulty with reading. The researchers compared the influence of text difficulty on reading ability growth over an 18-week period for 46 struggling readers who were engaged in one-on-one tutoring. Students were randomly assigned to either receive texts matched to their reading level or matched to their grade level. Three reading tests were used to estimate reading ability: the *Peabody Picture Vocabulary Test—Third Edition* (PPVT3), the *Woodcock Reading Mastery Tests—Revised (WRMT-R)*, and the *Analytic Reading Inventory (ARI)*. These tests were used in a pre-post research design. When groups were compared, students who received texts matched to their reading level made greater learning gains (evidenced by performance on several measures including three subtests of the *Woodcock Reading Mastery Tests-Revised*) as compared to those who received grade-level matched texts.

Research has shown clearly that there is a positive correlation between reading ability and the amount of reading students engage in throughout their schooling years (Cunningham & Stanovich, 1998; O'Connor, Swanson, & Geraghty, 2010; O'Connor, Bell, Harty, Larkin, Sackor, & Zigmond, 2002; Cain, Oakhill, & Lemmon, 2004; Jenkins, Stein, & Wysocki, 1984). When students are provided with materials that are appropriate for their reading ability level, they exhibit higher levels of understanding of what they read, and when they comprehend what they read, students may learn more. Thus, the more students read, the more likely they are to develop into strong readers. Studies investigating summer reading loss have shown that when students are provided with books at their reading level and interest areas, their gains in reading were comparable to gains one would expect in summer school (Kim, 2006). Since motivation is key to voluntary reading, two critical features of book selection are interest and reading level, and both were addressed in Kim's study. Kim demonstrated in a randomized field study that low-income students are not destined to summer loss; but rather, he showed that low-income students' skills could, in fact, grow over the summer if they were able to select books at their interest level and reading level. Kim used the Lexile Framework for Reading—a tool that many states use to ensure that students are appropriately challenged—to match students with texts at an appropriate complexity level.

Because the Lexile Theory provides complementary procedures for measuring people and text, the scale can be used to match a person's level of comprehension with books that the person is likely to read with a high comprehension rate. Trying to identify possible supplemental reading materials for students has, for the most part, relied on a teacher's familiarity with the titles. For example, an eighth-grade girl who is interested in sports but is not reading at grade level may be interested in reading a biography about Chris Evert. The teacher may not know, however, whether a specific biography is too difficult or too easy for the student. The Lexile Framework provides a reader measure and a text measure on the same scale. Armed with this information, a teacher, librarian, media specialist, student, or parent can plan for success.

Readers develop reading comprehension skills by reading. Skill development is enhanced when their reading is accompanied by frequent response requirements. Response requirements may be structured in a variety of ways. An instructor may ask oral questions as the reader progresses through the prose, or written questions may be embedded in the text, much as is done with the Reading Comprehension Assessment items. Response requirements are important; unless there is some evaluation and self-assessment, there can be no assurance that the reader is properly targeted and comprehending the material. Students need to be given a text on which they can practice being a competent reader (Smith, 1973). The above approach does not complete a fully articulated instructional

theory, but its prescription is straightforward. Students need to read more, and teachers need to monitor this reading with some efficient response requirement. One implication of these notions is that some of the time spent on skill sheets might be better spent reading targeted prose with concomitant response requirements (Anderson, Hiebert, Scott, & Wilkinson, 1985). This approach has been supported by the research of Five (1986) and Hiebert (1998).

As the reader improves, new titles with higher text measures can be chosen to match the growing reader ability. This results in a constantly growing person-measure, thus keeping the comprehension rate at the most productive level. We need to locate a reader's "edge" and then expose the reader to text that plays on that edge. When this approach is followed in any domain of human development, the edge moves and the capacities of the individual are enhanced.

What happens when the "edge" is overestimated and repeatedly exceeded? In physical exertion, if you push beyond the edge you feel pain; if you demand even more from a muscle, you will experience severe muscle strain or ligament damage. In reading, playing on the edge is a satisfying and confidence-building activity, but exceeding that edge by over-challenging readers with out-of-reach materials reduces self-confidence, stunts growth, and results in the individual "tuning out." The tremendous emphasis on reading in daily activities makes every encounter with written text a reconfirmation of a poor reader's inadequacy.

For individuals to become competent readers, they need to be exposed to text that results in a comprehension rate of 75% or better. If an 850L reader is faced with an 1100L text (resulting in a 50% comprehension rate), there will likely be too much unfamiliar vocabulary and too much of a load placed on the reader's tolerance for syntactical complexity for that reader to attend to meaning. The rhythm and flow of familiar sentence structures will be interrupted by frequent unfamiliar vocabulary, resulting in inefficient chunking and short-term memory overload. When readers are correctly targeted, they read fluidly with comprehension; when incorrectly targeted, they struggle both with the material and with maintaining their self-esteem. *Within the Lexile Framework, there are no poor readers—only mistargeted readers who are being overchallenged.*

Forecasting Comprehension Rates. A reader with a measure of 600L who is given a text measured at 600L is expected to have a 75% comprehension rate. This 75% comprehension rate is the basis for selecting text that is targeted to a reader's ability, but what exactly does it mean? And what would the comprehension rate be if this same reader were given a text measured at 350L or one at 850L?

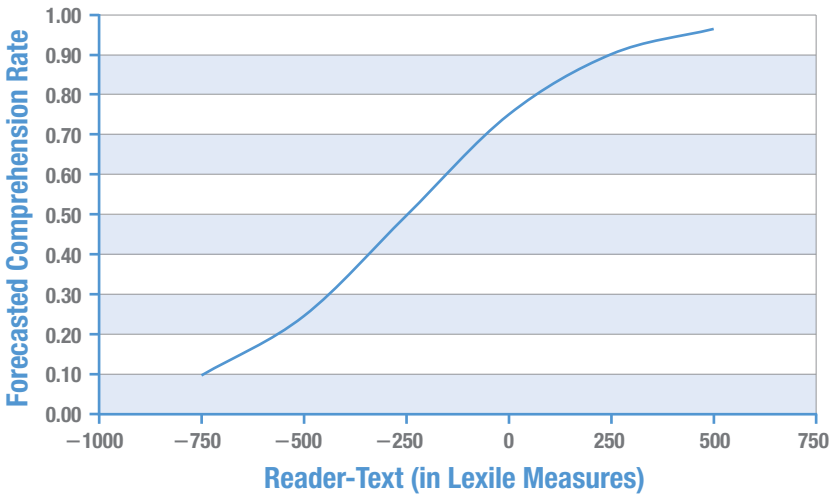
The 75% comprehension rate for a reader-text pairing can be given an operational meaning by imagining the text is carved into item-sized "chunks" of approximately 125–140 words with a question embedded in each chunk. A reader who answers three-fourths of the questions correctly has a 75% comprehension rate.

Suppose instead that the text and reader measures are not the same. The difference in Lexile units between reader and text governs comprehension. If the text measure is less than the reader measure, the comprehension rate will exceed 75%. If the text measure is much less, the comprehension rate will be much greater. But how much greater? What is the expected comprehension rate when a 600L reader reads a 350L text?

If all the item-sized chunks in the 350L text had the same calibration, the 250L difference between the 600L reader and the 350L text could be determined using the Rasch model equation (Equation 2 on page 71). This equation describes the relationship between the measure of a student's level of reading comprehension and the calibration of the items. Unfortunately, comprehension rates calculated only by this procedure would be biased because the calibrations of the slices in ordinary prose are not all the same. The average difficulty level of the slices *and* their variability both affect the comprehension rate.

Figure 6 shows the general relationship between reader-text discrepancy and forecasted comprehension rate. When the reader measure and the text calibration are the same, then the forecasted comprehension rate is 75%. In the example from the preceding paragraph, the difference between the reader measure of 600L and the text calibration of 350L is 250L. Referring to Figure 6 and using +250L (reader minus text), the forecasted comprehension rate for this reader-text combination would be 90%.

FIGURE 6. Relationship between reader-text discrepancy and forecasted reading comprehension rate.



Tables 6 and 7 show comprehension rates calculated for various combinations of reader measures and text calibrations.

TABLE 6. Comprehension rates for the same individual with materials of varying comprehension difficulty.

Reader Measure	Text Calibration	Sample Titles	Forecast Comprehension
1000L	500L	*Tornado* (Byars)	96%
1000L	750L	*The Martian Chronicles* (Bradbury)	90%
1000L	1000L	*Reader's Digest*	75%
1000L	1250L	*The Call of the Wild* (London)	50%
1000L	1500L	*On the Equality Among Mankind* (Rousseau)	25%

TABLE 7. Comprehension rates of different-ability readers with the same material.

Reader Measure	Calibration of Typical Grade 10 Textbook	Forecast Comprehension Rate
500L	1000L	25%
750L	1000L	50%
1000L	1000L	75%
1250L	1000L	90%
1500L	1000L	96%

The subjective experience of 50%, 75%, and 90% comprehension as reported by readers varies greatly. A 1000L reader reading 1000L text (75% comprehension) reports confidence and competence. Teachers listening to such a reader report that the reader can sustain the meaning thread of the text and can read with motivation and appropriate emotion and emphasis. In short, such readers appear to comprehend what they are reading. A 1000L reader reading 1250L text (50% comprehension) encounters so much unfamiliar vocabulary and difficult syntax that the meaning thread is frequently lost. Such readers report frustration and seldom choose to read independently at this level of comprehension. Finally, a 1000L reader reading 750L text (90% comprehension) reports total control of the text, reads with speed, and experiences automaticity during the reading process.

The primary utility of the Lexile Framework is its ability to forecast what happens when readers confront text. Every application by a teacher, student, librarian, or parent is a test of the Lexile Framework's accuracy. The Lexile Framework makes a point prediction every time a text is chosen for a reader. Anecdotal evidence suggests that the Lexile Framework predicts as intended. That is not to say the forecasted comprehension is error-free. There is error in text measures, reader measures, and their difference modeled as forecasted comprehension. However, the error is sufficiently small that the judgments about readers, texts, and comprehension rates are useful.

Performance Standard Proficiency Bands. A growing trend in education is to differentiate between *content standards*—curricular frameworks that specify what should be taught at each grade level—and *performance standards*—what students must do to demonstrate proficiency with respect to the specific content. Increasingly, educators and parents want to know more than just how a student's performance compares with that of other students; they ask, "What level of performance does a score represent?" and "How good is good enough?"

Description of the *Reading Inventory*

The Lexile Framework for Reading, in combination with the Reading Comprehension Assessment, provides a context for examining performance standards from two perspectives—reader-based standards and text-based standards. Reader-based standards are determined by examining the skills and knowledge of students identified as being at the requisite level (the examinee-centered method) or by examining the test items and defining what level of skills and knowledge the student must have to be at the requisite level (the task-centered method). A cut score is established that differentiates between students who have the desired level of skills and knowledge to be considered as meeting the standard and those who do not. Text-based standards are determined by specifying those texts that students with a certain level of skills and knowledge (for example, a high school graduate) should be able to read with a specified level of comprehension. A cut score is established that reflects this level of ability and is then annotated with benchmark texts descriptive of the standard.

In 1999, four performance standards were set at each grade level in the Reading Comprehension Assessment—Below Basic, Basic, Proficient, and Advanced. Proficient was defined as performance that exhibited competent academic performance when students read grade-level appropriate text and could be considered as reading "on Grade Level." Students performing at this level should be able to identify details, draw conclusions, and make comparisons and generalizations when reading materials developmentally appropriate for their nominal grade level.

In 2013, Scholastic expanded the Reading Comprehension Assessment item bank to better reflect the proportions of informational and literary materials students should be reading to be on track for college and career when they complete Grade 12. During this expansion, the decision was also made to revise the Reading Comprehension Assessment performance standards to reflect this emphasis on being college and career ready.

The following sources of data were examined to develop the Reading Comprehension Assessment performance standards:

- Reader-based standards: the North Carolina End-of-Grade and End-of-Course/English II assessments (North Carolina Department of Public Instruction, 2013 Lexile linking study, Grades 3–8 and English II); the Virginia Reading Standards of Learning Tests (Virginia Department of Education, 2013 Lexile Linking Study, Grades 3–8); the Kentucky Performance Rating for Educational Progress Reading Test (Kentucky Department of Education, 2012 Lexile Linking Study, Grades 3–8); and the Minnesota Comprehensive Assessment (MCA-III) (Minnesota Department of Education, 2013 Lexile Linking Study, Grades 3–8 and 10).
- Text-based standards: Common Core State Standards for English Language Arts—Appendix A, "Figure 3: Text Complexity Grade Bands and Associated Lexile Ranges (in Lexile measures)"; Lexile Grade Ranges: http://www.lexile.com/about-lexile/grade-equivalent/grade-equivalent-chart/); and Nelson, J., Perfetti, C., Liben, D., & Liben, M. (2011). *Measures of text difficulty: Testing their predictive value for grade levels and student performance*. New York: Student Achievement Partners.

Proficient was defined as the grade bands (and subsequent grade ranges) from the Common Core State Standards. The Common Core State Standards for English Language Arts focus on the importance of text complexity. As stated in Standard 10, students must be able to "read and comprehend complex literary and informational texts independently and proficiently" (Common Core State Standards for English Language Arts, College and Career Readiness Anchor Standards for Reading, NGA Center & CCSSO, 2010a, p.10). Students reading at this level are able to read at a comprehension level of at least 75% those materials that are associated with being on track for college and career readiness after Grade 12.

The policy descriptions for each of the performance standard proficiency bands used at each grade level are as follows:

- *Advanced:* Students scoring in this range exhibit superior performance when reading grade-level appropriate text and, in terms of their reading development, can be considered on track for college and career.
- *Proficient:* Students scoring in this range exhibit competent performance when reading grade-level appropriate text and, in terms of their reading development, can be considered on track for college and career.
- *Basic:* Students scoring in this range exhibit minimally competent performance when reading grade-level appropriate text and, in terms of their reading development, may be considered marginally on track for college and career.
- *Below Basic:* Students scoring in this range do not exhibit minimally competent performance when reading grade-level appropriate text and, in terms of their reading development, are not considered on track for college and career.

The final cut scores for each grade level in the Reading Comprehension Assessment are presented in Table 8.

TABLE 8. Performance standard proficiency bands for the Reading Comprehension Assessment, in Lexile measures, by grade.

Grade	Below Basic	Basic	Proficient	Advanced
K	N/A	BR	0L to 275L	280L and Above
1	BR	0L to 185L	190L to 530L	535L and Above
2	BR to 215L	220L to 415L	420L to 650L	655L and Above
3	BR to 325L	330L to 515L	520L to 820L	825L and Above
4	BR to 535L	540L to 735L	740L to 940L	945L and Above
5	BR to 615L	620L to 825L	830L to 1010L	1015L and Above
6	BR to 725L	730L to 920L	925L to 1070L	1075L and Above
7	BR to 765L	770L to 965L	970L to 1120L	1125L and Above
8	BR to 785L	790L to 1005L	1010L to 1185L	1190L and Above
9	BR to 845L	850L to 1045L	1050L to 1260L	1265L and Above
10	BR to 885L	890L to 1075L	1080L to 1335L	1340L and Above
11/12	BR to 980L	985L to 1180L	1185L to 1385L	1390L and Above

Reading Comprehension Assessment Readiness Standard. In addition to describing student reading performance at each grade level, the Reading Comprehension Assessment provides a Lexile measure that represents a student who is deemed ready for the reading demands of college and careers. Using the research of Williamson (2008), Stenner, Sanford-Moore, and Williamson (2012), and Williamson and Baker (2013), a Lexile measure of 1385L was defined as the cut point that could be used as the minimum reading level needed to be considered college and career ready.

Using *Reading Inventory* Results

The Foundational Reading Assessment

Performance on the Foundational Reading Assessment generates information that is relevant to instruction. The information is useful to teachers in that it shows them how students are performing and which students are likely to need additional support in attaining foundational literacy skills. Students who need similar levels and kinds of support are often grouped together for instruction.

The Foundational Reading Assessment provides a foundational fluency measure that can be reviewed against beginning, middle, and end-of-year grade-level benchmarks in order to measure students' progress in foundational reading skills. Teachers can administer the Foundational Reading Assessment in the beginning, middle, and end of the year to monitor student progress against the benchmarks. The benchmark skills that are assessed by the Foundational Reading Assessment are prerequisite skills for comprehending texts, and those foundational skills are typically developed during Grades K–2. Performance on the Foundational Reading Assessment determines student readiness for the Reading Comprehension Assessment.

The Reading Comprehension Assessment

Performance on the Reading Comprehension Assessment also generates information that is relevant to instruction. In the Reading Comprehension Assessment, the Lexile Framework for Reading provides teachers and educators with tools to help them link the results of assessment with subsequent instruction in reading comprehension. Tests, such as the Reading Comprehension Assessment, that are linked to the Lexile scale provide tools for monitoring the progress of students at any time during the school year.

When a reader takes the Reading Comprehension Assessment, his or her results are reported as a Lexile measure. This means, for example, that a student whose reading skills have been measured at 500L is expected to read with 75% comprehension a book that is also measured at 500L. When the reader and text are matched by their Lexile measures, the reader is "targeted." A targeted reader reports confidence, competence, and control over the text. When a text measure is 250L above the reader's measure, comprehension is predicted to drop to 50% and the reader experiences frustration and inadequacy. Conversely, when a text measure is 250L below the reader's measure, comprehension is predicted to increase to 90% and the reader experiences total control and automaticity.

Lexile Framework. The Lexile Framework for Reading is a tool that can help determine the reading level of written material—from a book, to a test item, to a magazine article, to a website, to a textbook. After test results are converted into Lexile measures, readers can be matched with materials on their own level. Over 100,000 books, 80 million periodical articles, and many newspapers have been leveled using this tool to assist in selecting reading materials.

Developed by the psychometric research company MetaMetrics, Inc., the Lexile Framework was funded in part by a series of grants from the National Institute of Child Health and Human Development. The Lexile Framework makes provisions for students who read below or beyond their grade level. See the Lexile Framework Map in Appendix A for fiction and nonfiction titles, leveled reading samples, and approximate grade ranges. A Lexile measure is the specific number assigned to any text. A computer program called the Lexile Analyzer® computes it. The Lexile Analyzer carefully examines the complete text to measure such characteristics as sentence length and word frequency—characteristics that are highly related to overall reading comprehension. The Lexile Analyzer then reports a Lexile measure for the text.

Using the Lexile Framework to Select Books. Teachers, parents, and students can use the tools provided by the Lexile Framework to select materials and/or to plan instruction. When teachers provide parents and students with lists of titles that match the students' Lexile measures, they can then work together to choose appropriate titles that also match the students' interest and background knowledge. *The Lexile Framework does not prescribe a reading program; it is a tool that gives educators more knowledge of the variables involved when they design reading instruction.* The Lexile Framework facilitates multiple opportunities for use in a variety of instructional activities. After becoming familiar with the Lexile Framework, teachers are likely to think of a variety of additional creative ways to use this tool to match students to books that they find challenging but not frustrating.

The Lexile Framework is a system that helps match readers with literature appropriate for their reading skills. When reading a book within their Lexile range (50L above to 100L below their Lexile measure), readers should comprehend enough of the text to make sense of it, while still being challenged enough to maintain interest and learning.

Many factors affect the relationship between a reader and a book. These factors include content, age of the reader, interest, suitability of the text, and text difficulty. The Lexile measure of a text, a measure of text difficulty, is a good starting point for the selection process; other factors should then be considered. The Lexile measure should never be the sole factor considered when selecting a text.

Helping Students Set Appropriate Learning Goals. Students' Lexile measures can be used to identify reading materials that they are likely to comprehend with 75% accuracy. Students can set goals for improving their reading comprehension and plan clear strategies to reach those goals, using literature from the appropriate Lexile ranges. Students can be retested using the Reading Comprehension Assessment during the school year to monitor their progress toward their goals.

Monitoring Progress Toward Reading Program Goals. As students' Lexile measures increase, their reading comprehension ability increases, and the set of reading materials they can comprehend at 75% accuracy expands. Many school districts are required to write school improvement plans that include measurable goals. Schools also write grant applications in which they are required to state how they will monitor progress of the intervention funded by the grant. For example, schools that receive Reading Excellence Act funds can use the Lexile Framework for evaluation purposes. Schools can use student-level and district-level Lexile information to monitor and evaluate interventions designed to improve reading skills.

Examples of measurable goals and clearly related strategies for reading intervention programs might include:

Goal: At least half of the students will improve their reading comprehension abilities by 100L after one year's use of an intervention.

Goal: Students' attitudes about reading will improve after reading 10 books at their 75% comprehension rate.

These examples of goals emphasize the fact that the Lexile Framework is not an intervention, but a tool to help educators plan instruction and measure the success of the reading program.

Communicating With Parents Meaningfully to Include Them in the Educational Process. Teachers can use the Lexile Framework to engage parents in the following sample exchanges: "Your child will be ready to read with at least 75% comprehension these materials from the next grade level"; "Your child will need to increase his or her Lexile measure by 400–500L in the next several years to prepare for the reading demands of college and career. Here is a list of appropriate titles your child can choose from for reading this summer."

Challenging the Best Readers. A variety of instructional programs are available for the poorest readers, but few resources are available to help teachers challenge their best readers. The Lexile Framework links reading comprehension levels to reading material for the entire range of reading abilities and will help teachers identify age-appropriate reading material to challenge the best readers.

Studies have shown that students who succeed in school without being challenged often develop poor work habits and unrealistic expectations of effortless success as adults. Even though these problems are not likely to be evidenced until the reader is beyond school age, providing appropriate-level curriculum to the best students may be as important as it is for the poorest-reading students.

Improving Students' Reading Fluency. Educational researchers have found that students who spend a minimum of three hours a week reading at their own level for their own purposes develop reading fluency that leads to improved mastery. Not surprisingly, researchers have also found that students who read age-appropriate materials with a high level of comprehension also learn to enjoy reading.

Teaching Learning Strategies by Controlling Comprehension Match. The Lexile Framework also permits a teacher to intentionally under- or over-target students when the teacher wants students to work on fluency and automaticity or wants to teach strategies for attacking "hard" text, respectively. For example, metacognitive ability has been well documented to play an important role in reading comprehension performance. When teachers know the level of texts that would challenge a group of readers, they can systematically plan instruction that will allow students to encounter difficult text in a controlled fashion and make use of instructional scaffolding to build student success and confidence with more challenging text. The teacher can model appropriate learning strategies for students, such as rereading or rephrasing text in one's own words, so that students can then learn what to do when comprehension breaks down. Then students can practice these metacognitive strategies on selected text while the teacher monitors their progress.

Teachers can use Lexile measures to guide a struggling student toward texts at the lower end of the student's Lexile range (between 100L below and 50L above his or her Lexile measure). Similarly, advanced students can be adequately challenged by reading texts at the midpoint of their Lexile range, or slightly above. Challenging new topics or genres may be approached in the same way.

Differentiating instruction for the reading experience also involves the student's motivation and purpose. If a student is highly motivated for a particular reading task (e.g., self-selected free reading), the teacher may suggest books higher in the student's Lexile range. If the student is less motivated or intimidated by a reading task, material at the lower end of his or her Lexile range can provide the basic comprehension support to keep the student from feeling overwhelmed.

Targeting Instruction to Students' Abilities. To encourage optimal progress with any reading materials, teachers need to be aware of the difficulty level of the text relative to a student's reading level. A text that is too difficult not only serves to undermine a student's confidence but also diminishes learning itself. A text that is too easy fosters bad work habits and unrealistic expectations that will undermine the later success of the best students.

When students confront new kinds of texts and text containing new content, their introduction can be softened and made less intimidating by guiding students to easier reading. On the other hand, students who are comfortable with a particular genre or format or the content of such texts can be challenged with more material from difficult levels, which will reduce boredom and promote the greatest improvement in vocabulary and comprehension skills.

To become better readers, students need to be continually challenged—they need to be exposed to less common and more difficult vocabulary in meaningful contexts. A 75% comprehension rate provides an appropriate level of challenge.

Applying Lexile Measures Across the Curriculum. Over 450 publishers Lexile their titles, enabling educators to make connections among all of the different components of the curriculum to plan instruction more effectively. Equipped with a student's Lexile measure, teachers can connect him or her to books and newspaper and magazine articles that have appropriate Lexile measures (visit www.lexile.com for more details).

Using Lexile Measures in the Classroom

- Develop individualized reading lists that are tailored to provide appropriately challenging reading while still reflecting student interests and motivation.
- Enhance thematic teaching by building text sets that include texts at varying levels. These texts might not only support the theme but also provide a way for all students to participate in the theme, building knowledge of common content for the class while building the reading skills of individual students. Such discussions can provide important collaborative brainstorming opportunities to fuel student writing and synthesize the curriculum.

- Sequence reading materials according to their difficulty. For example, choose one book a month for use as a read-aloud throughout the school year, then increase the difficulty of the books throughout the year. This approach is also useful for core programs or textbooks organized in anthology format. (Educators often find that they need to rearrange the order of the anthologies to best meet their students' needs.)
- Develop a reading folder that goes home with students and returns weekly for review. The folder can contain a reading list of reading texts within the student's Lexile range, reports of recent assessments, and a parent form to record reading that occurs at home. This is also an important opportunity to encourage individualized goal setting and engage families in monitoring the progress of students in reaching these goals.
- Use as an effective method to monitor progress toward individual reading goals and reading program goals. The Lexile measure is also a convenient measure to track student growth toward college and career readiness.
- Choose texts lower in a student's Lexile range when factors make the reading situation more challenging or unfamiliar. Select texts at or above a student's range to stimulate growth, when a topic holds high interest for a student, or when additional support such as background teaching or discussion is provided.
- Use to provide all students with exposure to differentiated, challenging text at least once every two to three weeks as suggested by the lead authors of the Common Core State Standards.
- Use the free Find A Book website (at www.lexile.com/fab) to support book selection and create booklists within a student's Lexile range to help the student make more informed choices when selecting texts.
- Use the database resources to infuse research into the curricula while tailoring reading selections to specific Lexile levels. In this way, students can explore new content at an appropriate reading level and then demonstrate their assimilation of that content through writing and/or presentations. A list of the database service providers that have had their collections measured can be found at www.lexile.com /using-lexile/lexile-at-library.

Using Lexile Measures in the Library

- Make the Lexile measures of books available to students to better enable them to find books of interest at their appropriate reading level.
- Compare student Lexile levels with the Lexile levels of the books and periodicals in the library to help educators analyze and develop the collection to more fully meet the needs of all students.
- Use the database resources to search for articles at specific Lexile levels to support classroom instruction and independent student research. A list of the database service providers that have had their collections measured can be found at www.lexile.com/using-lexile/lexile-at-library.
- Use the free Find A Book website (at www.lexile.com/fab) to support book selection and create booklists within a student's Lexile range to help the student make more informed choices when selecting texts.

Using Lexile Measures at Home

- Ensure that each child gets plenty of reading practice, concentrating on material within his or her Lexile range. Parents can ask their child's teacher or school librarian to print a list of books in their child's range or search the Lexile Titles Database.
- Communicate with the child's teacher and school librarian about the child's reading needs and accomplishments. They can use the Lexile scale to describe their assessment of the child's reading ability.

- When a reading assignment proves too challenging for a child, use activities to help. For example, review the words and definitions from the glossary and the study questions at the end of a chapter before the child reads the text. Afterwards, be sure to return to the glossary and study questions to make certain the child understands the material.
- Celebrate a child's reading accomplishments. The Lexile Framework provides an easy way for readers to track their own growth. Parents and children can set goals for reading—following a reading schedule, reading a book with a higher Lexile measure, trying new kinds of books and articles, or reading a certain number of pages per week. When children reach the goal, make it an occasion!

Limitations of the Lexile Framework. Just as variables other than temperature affect comfort, variables other than semantic and syntactic complexity affect reading comprehension ability. A student's personal interests and background knowledge are known to affect comprehension. We do not dismiss the importance of temperature simply because it alone does not dictate the comfort of an environment. Similarly, though the information communicated by the Lexile Framework is valuable, the inclusion of other information enhances instructional decisions. Parents and students should have the opportunity to give input regarding students' interests and background knowledge when test results are linked to instruction.

Reading Comprehension Assessment Results and Grade Levels. Lexile measures do not translate precisely to grade levels. Any grade will encompass a range of readers and reading materials. A fifth-grade classroom may include some readers who are far ahead of the majority of readers (about 250L above) and some readers who are far below the majority (about 250L below). To say that some books are "just right" for fifth graders assumes that all fifth graders are reading at the same level. The Lexile Framework can be used to match readers with texts at whatever level is appropriate.

Just because a student is an excellent reader does not mean that he or she would comprehend a text typical of a higher grade level. Without the requisite background knowledge, a student will still struggle to make sense of the text. A high Lexile measure for a grade indicates only that the student can read grade-level appropriate materials at a higher level of comprehension (e.g., 90%).

The real power of the Lexile Framework is in tracking readers' growth—wherever they may be in the development of their reading skills. Readers can be matched with texts that they are forecasted to read with 75% comprehension. As readers grow, they can be matched with more demanding texts. And, as texts become more demanding, readers grow.

Development of the *Reading Inventory*

Development of the *Reading Inventory*

The *Reading Inventory* consists of two subtests, the Foundational Reading Assessment and the Reading Comprehension Assessment. The Foundational Reading Assessment subtest was added to the *Reading Inventory* version for students in Grades K–2 who are still developing the foundational reading skills necessary for reading comprehension. The Foundational Reading Assessment was originally developed by Richard K. Wagner as a screener and placement assessment for *iRead,* a K–2 digital foundational reading program. The Foundational Reading Assessment can be used to assess the development of early literacy skills for students in Grades K–2, including phonological awareness, letter-sound and letter-word identification, decoding, and sight word recognition. The Reading Comprehension Assessment subtest is the new version of the *Reading Inventory* Enterprise Edition with updated items improving the overall item bank. It is based on the Lexile Framework for Reading and can be used to assess a student's reading ability or comprehension level, to match students with appropriate texts for successful reading experiences, and to provide students with "stretch" reading experiences aligned with college and career readiness with appropriate scaffolding.

The Foundational Reading Assessment Development

The Foundational Reading Assessment Strands

The Foundational Reading Assessment includes a total of 82 possible items, divided into three strands: Phonological Awareness, Letter-Word Identification, and Word Attack. The three strands combine into a total accuracy and total fluency score.

- The Phonological Awareness Strand includes 12 total items, specifically three items designed to measure students' rhyme identification skills, and nine items designed to measure students' ability to identify initial, final, and medial sounds.
- The Letter-Word Identification Strand includes 30 total items, specifically 10 items designed to measure students' knowledge of uppercase and lowercase letter names, and 20 items designed to measure students' sight word knowledge.
- The Word Attack Strand includes 40 total items, specifically 10 items designed to measure students' ability to identify letter sounds, and 30 nonword items designed to measure students' decoding skills.

Development of the Foundational Reading Skills Item Bank

Phonological Awareness Items. Four phonological awareness item types were created. Rhyme items require identifying a response alternative that shares a rhyme with a target real-word stimulus. Initial sound items require identifying a response alternative that shares an initial sound with a target real-word stimulus. Final sound items require identifying a response alternative that shares a final sound with a target real-word stimulus. Medial sound items require identifying a response alternative that shares a medial sound with a target real-word stimulus. Five items were initially generated for each item type, and item discrimination and difficulty values were used to select the best three items for each of the four item types to be included in the final version of the Foundational Reading Assessment, resulting in a total of 12 phonological awareness items.

Letter Name and Letter Sound Knowledge Items. Ten items assessing lowercase letter name knowledge and 10 items assessing uppercase letter name knowledge were initially developed. Item discrimination and difficulty values were used to select the best five uppercase and five lowercase items, for a total of 10 letter name knowledge items. Ten letter sound knowledge items were developed, and item discrimination and difficulty values indicated that all 10 letter sound items should be included in the Foundational Reading Assessment.

Sight Word Reading Items. A total of 20 sight word items were developed using the 100 most frequent words from Fry's (2000) *1000 Instant Words.* The distractor items were other high-frequency sight words or common decodable words. Item discrimination and difficulty values indicated that all 20 sight word items should be included on the Foundational Reading Assessment.

Nonword Items. A total of 30 nonword items were developed, representing the full range of commonly taught phonics skills. All targets and distractors were nonwords or obscure English words that are unlikely to be known. In addition, all targets and distractors follow conventions of English spelling, and care was taken to avoid Spanish words, slang, and nonwords that sounded like real words. Item discrimination and difficulty values indicated that all 30 nonword items should be included on the Foundational Reading Assessment.

Foundational Reading Assessment Development and Evaluation Sample

The Foundational Reading Assessment development and evaluation sample consisted of 1,390 students from 75 classrooms, representing four school districts in geographically dispersed regions of the United States. The sample included 457 kindergarten students, 498 first-grade students, and 425 second-grade students. Nearly a third (31%) of the students in the sample were Caucasian, 29% were Hispanic, 18% were African American, 16% were Asian, and 6% of the students were comprised of other ethnicities. The sample consisted of 51% male and 49% female students. Over half (52%) the sample received free or reduced-price lunch, and 18% were English language learners (ELLs).

The representativeness of the sample with respect to reading skills is evidenced by the percentages of students who fell in the various categories of performance based on their DIBELS Next beginning-of-year composite scores (administered in September and October 2012). These results are presented in Table 9.

TABLE 9. Percentages of students falling in three DIBELS Next beginning-of-year composite score benchmark classifications.

DIBELS NEXT COMPOSITE SCORE			
	Kindergarten	**First Grade**	**Second Grade**
At or Above Benchmark	60%	55%	49%
Below Benchmark	17%	14%	5%
Well Below Benchmark	23%	31%	46%

These results indicate that the sample included considerable numbers of students who performed either At or Above Benchmark or Well Below Benchmark in reading as measured by DIBELS Next. The trend across grades was for fewer students to be At or Above Benchmark and more to be Below Benchmark or Well Below Benchmark with increasing grade level.

Foundational Reading Assessment Scoring Algorithm

Item-Level Fluency Thresholds. Fluency thresholds were determined empirically for each item. Alternative procedures for setting fluency thresholds were evaluated on the basis of the resultant item and scale properties. The procedure was adopted to set the item fluency threshold at the 25th percentile of response times for the first-grade sample, after response times were ordered from fastest to slowest.

Combining Accuracy and Latency Into Fluency Scores. A fluent response must be accurate as well as sufficiently fast. To get credit for a fluent response to an item, the response had to be correct and the total response time (latency) could not exceed the threshold time. This method of scoring is represented in Table 10.

TABLE 10. Combining accuracy and latency into fluency scores: Four possible response patterns.

Pattern	Response Accurate?	Latency Below Threshold?	Fluency Score
1	No	No	0
2	No	Yes	0
3	Yes	No	0
4	Yes	Yes	1

There are a number of advantages to this kind of scoring. First, this method of scoring produces "hybrid" scores that combine accuracy and speed of responding. Hybrid scores have proven to be effective on other reading measures such as the *Test of Word Reading Efficiency, Second Edition (TOWRE-2)* (Torgesen, Wagner, & Rashotte, 2012) and the *Test of Silent Reading Efficiency and Comprehension (TOSREC)* (Wagner, Torgesen, Rashotte, & Pearson, 2010). One reason that hybrid scores are effective is that individual and developmental differences in underlying reading skill affect both accuracy and speed of response. Therefore, a score that incorporates both speed and accuracy is better than one that is based on only speed or accuracy.

A second advantage of this method of scoring is that outlying response times are handled implicitly. If performance on an assessment is measured in terms of average response time, a practical problem that must be dealt with is what to do about outlying response times. For example, an outlying response time of 20 seconds will have a large impact on the average response time for a set of responses that typically fall in the range of 1 to 2 seconds. The scoring method used on the Foundational Reading Assessment handles this potential problem in that a response that exceeds the threshold value gets an item fluency score of 0 regardless of how slow it is.

A third advantage of this method of scoring is that it handles a practical problem that arises in the Foundational Reading Assessment. Because the cursor must be moved to select the correct response in a list of distractors, the amount of cursor movement required varies across items depending on the position of the target item in the list of distractors. This presumably affects response times. This potential unwanted source of variability is handled implicitly by the fact that item thresholds are determined empirically for each individual item. Differences in response time associated with differences in amount of cursor movement required are reflected in the empirical distribution of response times that are the basis of the analyses used to identify the optimal item threshold.

A final advantage of this method of scoring is that it facilitates maximal use of the information gained from responses to all items, ranging from easier sight word items to more difficult nonword items. When only accuracy of responses are considered, ceiling effects can be common for easy items (e. g., cat) with nearly all children getting the item correct. But by considering fluency, thereby requiring that the response be made prior to the item threshold response time, the ceiling effect on accuracy can be minimized and the item becomes more informative about a child's level of performance.

Summary of the Development of the Foundational Reading Assessment Scores. The Foundational Reading Assessment fluency scores are based on both the accuracy and speed of responses. Response thresholds were established individually for each item.

The Reading Comprehension Assessment Development

The *Reading Inventory* was originally developed to assess a student's overall level of reading comprehension based on the Lexile Framework. *Reading Inventory* Reading Comprehension Assessment is an extension of the test development work begun in the 1980s and 1990s on the Early Learning Inventory (MetaMetrics, 1995) and the Lexile Framework, which was funded by a series of grants from the National Institute of Child Health and Human Development. The Early Learning Inventory was developed for use in Grades 1–3 as an alternative to many standardized assessments of reading comprehension; it was neither normed nor timed and was designed to examine a student's ability to read text for meaning.

Item development and test development are interrelated processes; for the purpose of this document they will be treated as independent activities. A bank of approximately 3,000 items was developed for the initial implementation of the *Reading Inventory*. Two subsequent item development phases were completed in 2002 and 2003, with a third phase being completed during Fall 2013 and Winter 2014, adding a total of more than 5,000 items to the *Reading Inventory* Reading Comprehension Assessment subtest.

The *Reading Inventory* was first developed as a print-based assessment. Two parallel forms of the assessment (A and B) were developed during 1998 and 1999. Also in 1998, Scholastic decided to develop a computer-based, interactive version of the assessment. Version 1 of *Reading Inventory*-Interactive was launched in Fall 1999. Subsequent computer-based, interactive versions were launched between 1999 and 2003, with version 4/Enterprise Edition launched in Winter 2006. The version of *Reading Inventory* launched in August 2014 is available only as a computer-based interactive version.

Development of the Reading Comprehension Item Bank

Passage Selection. Standard 10 of the Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects (National Governors Association Center for Best Practices [NGA Center] & the Council of Chief State School Officers [CCSSO], 2010a) states that all students must demonstrate the ability to "[r]ead and comprehend complex literary and informational texts independently and proficiently" (pp. 10, 35). One way that the quantitative aspects of text complexity can be described is by the Lexile measure of the text.

Passages selected for use on the Reading Comprehension Assessment came from "real world" reading materials that students may encounter both in and out of the classroom. Sources included school textbooks, literature, and periodicals from a variety of interest areas and material written by authors of different backgrounds. The following criteria were used to select passages:

- The passage must develop one main idea or contain one complete piece of information.
- Understanding of the passage is independent of the information that comes before or after the passage in the source text.
- Understanding of the passage is independent of prior knowledge not contained in the passage.

With the aid of a computer program, item writers examined prose excerpts of 125 or fewer words in length that included a minimum of three sentences and were calibrated to within 150L (and generally within 100L) of the source text. This process, called source targeting, uses information from an entire text to ensure that the estimated syntactic complexity and semantic demand of an excerpted passage are consistent with the "true" reading demand of the source text. From these passages the item writers were asked to select four to five that could be developed as items. If it was necessary to shorten or lengthen the passage in order to meet the criteria for selection, the item writer could immediately recalibrate the passage to ensure that it was still targeted to within 100L of the complete text.

During the 2013–2014 phase of passage development, passages below 400L in text complexity were commissioned to be appropriate for students in the early grades (i.e., kindergarten and Grades 1 and 2). Passages consisted of one to five sentences depending on the level of the text, with lower texts (below 0L) consisting of one sentence and higher level texts (200L to 390L) consisting of 3 or more sentences. Lower-level passages focused on decodable and high-frequency sight words; used the *iRead* Word List, Series 1–25, as a guide for the types of words students should be familiar with; and limited punctuation to periods, question marks, and quotations. Higher-level passages required fewer restrictions on the words used, but did attend to the use of decodable and high-frequency sight words; used the *iRead* Word List, Series 41–50, as a guide for the types of words students should be familiar with at this level; and employed some complex sentences (modifiers, clauses, varied punctuation including dashes, etc.).

Item Writing—Format. The traditional cloze procedure for item creation is based on deleting every fifth to seventh word (or some variation) regardless of its part of speech (Bormuth, 1967, 1968, 1970). Certain categories of words can also be selectively deleted. Selective deletions have shown greater instructional effects than random deletions. Evidence shows that cloze items reveal both text comprehension and language mastery levels. Some of the research on metacognition shows that better readers use more strategies (and, more importantly, appropriate strategies) when they read. Cloze items have been shown to require more rereading of the passage and increased use of context clues.

The Reading Comprehension Assessment consists of embedded completion items. Embedded completion items are an extension of the cloze format, similar to fill-in-the-blank. When properly written, this item type directly assesses a reader's ability to draw inferences and establish logical connections among the ideas in a passage. The Reading Comprehension Assessment presents a reader with a passage of approximately 30 to 150 words in length (less at the very lowest levels). Passages are shorter for beginning readers and longer for more advanced readers. The passage is then response illustrated—a statement with a word missing is added at the end of the passage, followed by four options. From the four presented options, a reader is asked to select the "best" option to complete the statement.

Items were written so that the correct response is not stated directly in the passage, and the correct answer cannot be suggested by the item itself. Rather, the examinee must determine the correct answer by comprehending the passage. The four options derive from the Lexile Vocabulary Analyzer word list that corresponds with the Lexile measure of the passage. In this format, all options are semantically and syntactically appropriate completions of the sentence, but one option is unambiguously "best" when considered in the context of the passage. This format is "well-suited for testing a student's ability to evaluate" (Haladyna, 1994, p. 62). In addition, this format is useful instructionally. This inferential level is consistent with Depth of Knowledge (DOK) Level 2 (skills and concepts) and Level 3 (strategic thinking) (Webb, 2007).

- Level 2 (skills and concepts) includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is more complex than in Level 1. Keywords that generally distinguish a Level 2 item include *classify*, *organize*, *estimate*, *make observations*, *collect and display data*, and *compare data*.
- Level 3 (strategic thinking) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The complexity results because the multistep task requires more demanding reasoning.

The statement portion of the embedded completion item can assess a variety of skills related to reading comprehension: paraphrase information in the passage; draw a logical conclusion based on information in the passage; make an inference; identify a supporting detail; or make a generalization based on information in the passage. The statements were written to ensure that by reading and comprehending the passage, the reader can select the correct option. When the statement is read by itself, each of the four options is plausible.

There are two main advantages to using embedded completion items on the Reading Comprehension Assessment. The first is that the reading difficulty of the statement and the four options is designed to be easier than the most difficult word in the passage. The second advantage of the embedded completion format is that when authentic passages are used, no attempt is made to control the length of sentences or level of vocabulary in the passage. However, for authentic and commissioned passages, the embedded completion statement is written to be below the overall reading difficulty of the passage text, consisting of short, clear statements. These advantages help ensure that the statement is easier than the accompanying passage.

Item Writing—Training. Item writers for the Reading Comprehension Assessment were educators and item development specialists who had experience with the everyday reading ability of students at various levels. In 1998 and 1999, 12 individuals developed items for Forms A and B of the Reading Comprehension Assessment and the second set of items. In 2003 and 2008, six individuals developed items for the third and fourth sets. In 2013–2014, 13 individuals developed items for the fifth set. Using individuals with these experiences helped to ensure that the items are valid measures of reading comprehension. Item writers were provided with training materials concerning the embedded completion item format and guidelines for selecting passages, developing statements, and selecting options. The item writing materials also contained model items that illustrated the criteria used to evaluate items and corrections based on those criteria. The final phase of item writer training was a short practice session with three to five items.

Item writers were provided vocabulary lists to use during statement and option development. The vocabulary lists were compiled by MetaMetrics based on research to determine the Lexile measures of words (i.e., their difficulty). The Lexile Vocabulary Analyzer (LVA) determines the Lexile measure of a word using a set of features related to the source text and the word's prevalence in the MetaMetrics corpus (MetaMetrics, 2006b). The rationale used to compile the vocabulary lists was that the words should be part of a reader's "working" vocabulary if they had likely been encountered in easier text (those with lower Lexile measures).

Item writers were also given extensive training related to "sensitivity" issues. Part of the item writing materials addressed these issues and identified areas to avoid when selecting passages and developing items. The following areas were identified: violence and crime, depressing situations/death, offensive language, drugs/alcohol/tobacco, sex/attraction, race/ethnicity, class, gender, religion, supernatural/magic, parent/family, politics, animals/environment, and brand names/junk food. These materials were developed based on standards published by CTB/McGraw-Hill for universal design and fair access—equal treatment of the sexes, fair representation of minority groups, and the fair representation of disabled individuals *(Guidelines for Bias-Free Publishing)* and enhanced by Scholastic Inc.

Item writers were first asked to develop 10 items independently. The items were then reviewed for item format, grammar, and sensitivity. Based on this review, item writers received feedback and more training if necessary. Item writers were then asked to develop additional items.

Item Writing—Review. All items were subjected to a two-stage review process. First, items were reviewed and edited according to the criteria identified in the item-writing materials and for sensitivity issues. Approximately 25% of the items developed were rejected for various reasons. Where possible, items were edited and maintained in the item bank.

Items were then reviewed and edited by a group of specialists representing various perspectives—test developers, editors, and curriculum specialists. These individuals examined each item for sensitivity issues and the quality of the response options. During the second stage of the item review process, items were either "approved as presented," "approved with edits," or "deleted." Approximately 10 percent of the items written were approved with edits or deleted at this stage. When necessary, item writers received additional feedback and training.

The Reading Comprehension Assessment Item Bank Specifications. Five sets of items were developed between 1998 and 2014. Set 1 was developed in 1998 and used with the print and online versions of the test. Item specifications required that the majority of the items be developed for the 500L through 1100L range (70% of the total number of items; 10% per Lexile zone) with 15% below this range and 15% above this range. This range is typical of the majority of readers in Grades 3–9. Set 2 was written in Fall 2002 and followed the same specifications. Set 3 was written in Spring and Summer 2003. This set of items was developed for a different purpose—to provide items that would be interesting and developmentally appropriate for students in middle and high school, but written at a lower Lexile level (below the 50th percentile) than would typically be administered to students in these grades. Set 4 was written in 2008 to expand the number of items at high Lexile ranges (1300L and above) and provide opportunities to more precisely measure student reading ability at higher levels. Set 5 was written in Fall 2013 and Winter 2014. This set of items was developed for two purposes—(1) to increase the proportion of informational (nonfiction) items in the standard item bank and (2) to provide items that would be interesting and developmentally appropriate for students in middle and high school, but written at a lower Lexile level (below the 50th percentile) than would typically be administered to students in these grades. A total of 5,835 items were submitted to Scholastic for inclusion in the Reading Comprehension Assessment. Table 11 presents the number of items developed for each item set by Lexile zone.

TABLE 11. Distribution of items in *Reading Inventory* item bank, by Lexile zone.

Lexile Zone	Item Set 1 Original Item Bank	Item Set 2 Item Bank Expansion	Item Set 3 "Hi-Lo" Item Bank	Item Set 4 "High End" Items	Item Set 5 Standard and "Hi-Lo" Item Bank
BR (0L and Below)	22	15	–	–	51
1L to 100L	10	6	–	–	51
101L to 200L	45	13	–	–	50
201L to 300L	55	23	16	–	53
301L to 400L	129	30	91	–	60
401L to 500L	225	58	169	–	45
501L to 600L	314	96	172	–	43
601L to 700L	277	91	170	–	24
701L to 800L	332	83	131	–	30
801L to 900L	294	83	76	–	30
901L to 1000L	294	83	37	–	3
1001L to 1100L	335	84	2	–	3
1101L to 1200L	304	88	–	–	6
1201L to 1300L	212	76	–	–	6
1301L to 1400L	110	79	–	34	7
1401L to 1500L	42	57	–	82	2
1501L to 1600L	15	35	–	140	–
1601L to 1700L	–	–	–	146	–
1701L and Above	–	−1,000	–	90	–
Total	**3,015**	**1,000**	**864**	**492**	**464**

Differential Item Functioning Study. Differential item functioning (DIF) examines the relationship between the score on an item and group membership while controlling for ability. For an item to display DIF, people from different groups with the same underlying true ability must have different probabilities of giving a certain response. An item will not display DIF if people from different groups have different probabilities of giving a certain response (Embretson & Reise, 2000). The Mantel-Haenszel (MH) procedure (1959) was introduced to psychometrics by Holland and Thayer in 1988 to study group differences on dichotomously scored items (Camilli, 2006). This procedure has become "the most widely used methodology [to examine differential item functioning] and is recognized as the testing industry standard" (Roussos, Schnipke, & Pashley, 1999, p. 293).

The Mantel-Haenszel procedure examines DIF by examining *j* 2 x 2 contingency tables, where *j* is the number of different levels of ability actually achieved by the examinees (actual total scores received on the test). The focal group is the group of interest and the reference group serves as a basis for comparison for the focal group (Dorans and Holland, 1993; Camilli & Shepherd, 1994).

The Mantel-Haenszel chi-square statistic tests the alternative hypothesis that there is a linear association between the row variable (score on the item) and the column variable (group membership). The χ^2 distribution has 1 degree of freedom and is determined as

$$Q_{MH} = (n - 1)r^2 \qquad \text{(Equation 1)}$$

where *r* is the Pearson correlation between the row variable and the column variable (SAS Institute, 1985).

The Mantel-Haenszel Log Odds Ratio statistic, or estimated effect size, is used to determine the direction of differential item functioning (SAS Institute Inc., 1985). This measure is obtained by combining the odds ratios, α_j, across levels with the formula for weighted averages (Camilli & Shepherd, 1994, p. 110):

$$\alpha_j = \frac{p_{Rj}/q_{Rj}}{p_{Fj}/q_{Fj}} = \frac{\Omega_{Rj}}{\Omega_{Fj}} \qquad \text{(Equation 2)}$$

For this statistic, the null hypothesis of no relationship between score and group membership, or that the odds of getting the item correct are equal for the two groups, is not rejected when the odds ratio equals 1. For odds ratios greater than 1, the interpretation is that an individual at score level *j* of the Reference Group has a greater chance of answering the item correctly than an individual at score level *j* of the Focal Group. Conversely, for odds ratios less than 1, the interpretation is that an individual at score level *j* of the Focal Group has a greater chance of answering the item correctly than an individual at score level *j* of the Reference Group.

Educational Testing Service (ETS) classifies DIF based on the MH D-DIF statistic (Zwick, 2012), developed by Holland and Thayer, which is defined as

$$MH\ D - DIF = -2.35\ln(\alpha_j) \qquad \text{(Equation 3)}$$

Within Winsteps (Linacre, 2011), items are classified according to the ETS DIF Categories in Table 12 below. This classification system has been in place for more than 25 years.

TABLE 12. ETS DIF categories.

ETS DIF Category	MH D-DIF Statistic	DIF Interpretation
A	|DIF| $<$ 1 and not significant at .05 level	negligible or nonsignificant DIF
B	1 $\leq$ |DIF| $<$ 1.5	slight to moderate DIF
C	|DIF| $\geq$ 1.5 and significant at .05 level	moderate to large DIF

During the 2012–2013 school year, the Reading Comprehension Assessment was administered to 3,488 students in Grades 2–12 in a large, midwestern, urban district (San Antonio Independent School District, Texas). The sample of 3,488 students consisted of 2,818 students (80.8%) classified as Hispanic (district: 91.3%) and 3,010 students (86.3%) classified as Economically Disadvantaged (district: 92.8%).

For this DIF study, all students who participated in a Reading Comprehension Assessment administration and had associated demographic information (initial district sample: 33,562 students; final sample: 3,488, 10.4%) were included in the DIF analyses for a total of 11,125 administrations of the Reading Comprehension Assessment. The following student demographic classifications across test administrations were examined:

- *Gender:* Male ($N = 2{,}204$) and Female ($N = 1{,}255$); number of items examined = 1,445
- *Race/Ethnicity:* Focus—Hispanic ($N = 8{,}950$) and Reference—Caucasian, African American, Native American, and Asian/Pacific Islander ($N = 2{,}121$); number of items examined = 1,171
- *English as Second Language (ESL) Flag:* Yes ($N = 642$) and No ($N = 2{,}846$); number of items examined = 1,149
- *Economically Disadvantaged Flag:* No ($N = 478$) and Yes ($N = 3{,}010$); number of items examined = 901
- *Disabilities Flag:* Yes ($N = 2{,}034$) and No ($N = 1{,}454$); number of items examined = 1,387

Table 13 presents the results from examining the differential functioning of items (DIF) on the Reading Comprehension Assessment. This study examined 1,445 of the 5,119 items in the system (28.2%). An additional 3,188 items (62.3%) were administered during this time period, but a sufficient number of students did not complete each item to be included in the analyses. Because the Reading Comprehension Assessment is a computer-adaptive assessment and students are administered items calibrated in the Lexile metric closest to their Lexile measure (scale score), there is only one bank of items to examine.

TABLE 13. Reading Comprehension Assessment differential item functioning, by comparison groups.

Comparison	Number of Items Exhibiting Category A DIF	Number of Items Exhibiting Category B DIF	Number of Items Exhibiting Category C DIF
Gender	1,443 (99.9%)	1 (0.1%)	1 (0.1%)
Race/Ethnicity	1,169 (99.8%)	2 (0.2%)	0 (0.0%)
English as Second Language (ESL) Flag	1.146 (99.7%)	2 (0.2%)	1 (0.9%)
Economically Disadvantaged Flag	899 (99.8%)	0 (0.0%)	2 (0.2%)
Disabilities Flag	1,385 (99.9%)	0 (0.0%)	2 (0.1%)

Across the 1,445 Reading Comprehension Assessment items examined in this study, less than 1% of the items showed Class C DIF in relation to gender, race/ethnicity, English as a second language status, economically disadvantaged status, and disabilities flag. If a value of 3% is used as an estimate of the number of items on an assessment typically exhibiting Class C DIF, then none of the results are significantly different from that which would be expected by chance at the .05 level. Of the 6 Reading Comprehension Assessment items exhibiting Class C DIF in Table 13, a closer examination showed that there was no discernible pattern in relation to the Lexile zones (text complexity/item difficulty).

Reading Comprehension Assessment Computer-Adaptive Algorithm

School-wide tests are often administered at grade level to large groups of students in order to make decisions about students and schools. Consequently, since all students in a grade are given the same test, each test must include a wide range of items to cover the needs of both low- and high-achieving students. These wide-range tests are often unable to measure some students as precisely as a more focused assessment could.

To provide the most accurate measure of a student's level of reading ability, it is important to assess the student's reading level as precisely as possible. One method is to use as much background information as possible to target a specific test level for each student. This information can consist of the student's grade level, a teacher's judgment concerning the reading level of the student, or the student's standardized test results (e.g., scale scores, percentiles, stanines). This method requires the test administrator to administer multiple test forms during one test session, which can be cumbersome and may introduce test security problems.

With the widespread availability of computers in classrooms and schools, another more efficient method is to administer a test tailored to each student—computer-adaptive testing (CAT). Computer-adaptive testing is conducted individually with the aid of a computer algorithm to select each item so that the greatest amount of information about the student's ability is obtained before the next item is selected. The Reading Comprehension Assessment employs such a methodology for testing online.

What Are the Benefits of Computer-Adaptive Testing? Many benefits of computer-adaptive testing have been described in the literature (Wainer et al., 1990; Petty, 1995; Stone & Lunz, 1994; Wang & Vispoel, 1998). The benefits include the following:

- Increased efficiency through reduced testing time and targeted testing. Each test is tailored to the student. Item selection is based on the student's ability and responses to each question.
- Immediate scoring. A score can be reported as soon as the student finishes the test.
- More control over the test item bank. Because the test forms do not have to be physically developed, printed, shipped, administered, or scored, a broader range of forms can be used.

In addition, studies conducted by Hardwicke and Yoes (1984) and Schinoff and Steed (1988) provide evidence that below-level students tend to prefer computer-adaptive tests because they do not discourage students by presenting a large number of questions that are too hard for them (cited in Wainer, 1992).

Bayesian Paradigm and the Rasch Model. Bayesian methodology provides a paradigm for combining prior information with current data, both subject to uncertainty, to produce an estimate of current status, which is again subject to uncertainty. Uncertainty is modeled mathematically using probability.

Within the Reading Comprehension Assessment, prior information can be the student's current grade level, the student's performance on previous assessments, or teacher estimates of the student's abilities. The current data in this context is the student's performance on the Reading Comprehension Assessment, which can be summarized as the number of items answered correctly from the total number of items attempted.

Both prior information and current data are represented by probability models reflecting uncertainty. The need to incorporate uncertainty when modeling prior information is intuitively clear. The need to incorporate uncertainty when modeling test performance is, perhaps less intuitive. When the test has been taken and scored, and assuming that no scoring errors were made, the performance, i.e., the raw score, is known with certainty. Uncertainty arises because test performance is associated with but not wholly determined by the ability of the student, and it is that ability, rather than the test performance per se, that we are trying to measure. Thus, though the test results reflect the test performance with certainty, we remain uncertain about the ability that produced the performance.

The uncertainty associated with prior knowledge is modeled by a probability distribution for the ability parameter. This distribution is called the prior distribution, and it is usually represented by a probability density function, e.g., the normal bell-shaped curve. The uncertainty arising from current data is modeled by a probability function for the data when the ability parameter is held fixed. When roles are reversed so that the data are held fixed and the ability parameter is allowed to vary, this function is called the likelihood function. In the Bayesian paradigm, the posterior probability density for the ability parameter is proportional to the product of the prior density and the likelihood, and this posterior density is used to obtain the new ability estimate along with its uncertainty.

The computer-adaptive algorithm used with the Reading Comprehension Assessment is also based on the Rasch (one-parameter) item-response theory model. Classical test theory has two basic shortcomings: (1) the use of item indices whose values depend on the particular group of examinees from which they were obtained, and (2) the use of examinee ability estimates that depend on the particular choice of items selected for a test. The basic premises of item-response theory (IRT) overcome these shortcomings by predicting the performance of an examinee on a test item based on a set of underlying abilities (Hambleton & Swaminathan, 1985). The relationship between an examinee's item performance and the set of traits underlying item performance can be described by a monotonically increasing function called an item characteristic curve (ICC). This function specifies that as the level of the trait increases, the probability of a correct response to an item increases.

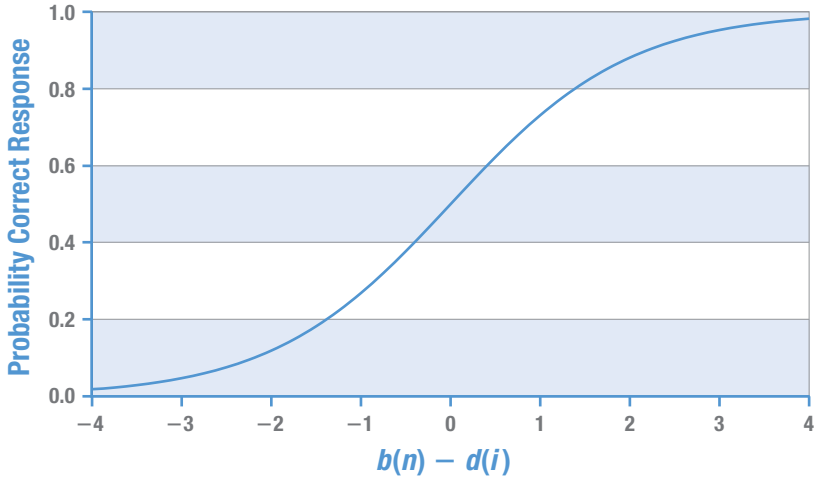
The conversion of observations into measures can be accomplished using the Rasch (1980) model, which requires that item calibrations and observations (count of correct items) interact in a probability model to produce measures. The Rasch item-response theory model expresses the probability that a person (n) answers a certain item (i) correctly by the following relationship:

$$P_{ni} = \frac{e^{b_n - d_i}}{1 + e^{b_n - d_i}} \qquad \text{(Equation 4)}$$

where d_i is the difficulty of item i ($i = 1, 2, \ldots,$ number of items); b_n is the ability of person n ($n = 1, 2, \ldots,$ number of persons); $b_n - d_i$ is the difference between the ability of person n and the difficulty of item i; and P_{ni} is the probability that examinee n responds correctly to item i (Hambleton & Swaminathan, 1985; Wright & Linacre, 1994).

This measurement model assumes that item difficulty is the only item characteristic that influences the examinee's performance such that all items are equally discriminating in their ability to identify low-achieving persons and high-achieving persons (Bond & Fox, 2001; and Hambleton, Swaminathan, & Rogers, 1991). In addition, the lower asymptote is zero, which specifies that examinees of very low ability have zero probability of correctly answering the item. The Rasch model has the following assumptions: (1) unidimensionality—only one ability is assessed by the set of items; and (2) local independence—when abilities influencing test performance are held constant, an examinee's responses to any pair of items are statistically independent (conditional independence, i.e., the only reason an examinee scores similarly on several items is because of his or her ability, not because the items are correlated). The Rasch model is based on fairly restrictive assumptions, but it is appropriate for criterion-referenced assessments. Figure 7 shows the relationship between the difference of a person's ability and an item's difficulty and the probability that a person will respond correctly to the item.

FIGURE 7. The Rasch Model—the probability person *n* responds correctly to item *i*.



An assumption of the Rasch model is that the probability of a response to an item is governed by the difference between the item calibration (d_i) and the person's measure (b_n). From an examination of the graph in Figure 7, when the ability of the person matches the difficulty of the item ($b_n - d_i = 0$), then the person has a 50% probability of responding to the item correctly. With the Lexile Framework, 75% comprehension is modeled by subtracting a constant.

The number correct for a person is the probability of a correct response summed over the number of items. When the measure of a person greatly exceeds the calibration (difficulties) of the items ($b_n - d_i > 0$), then the expected probabilities will be high and the sum of these probabilities will yield an expectation of a high number correct. Conversely, when the item calibrations generally exceed the person measure ($b_n - d_i < 0$), the modeled probabilities of a correct response will be low and a low number correct is expected.

Thus, Equation 2 can be rewritten in terms of a person's number of correct responses on a test

$$O_p = \sum_{i=1}^{L} \frac{e^{b_n - d_i}}{1 + e^{b_n - d_i}} \qquad \text{(Equation 5)}$$

where O_p is the number of person p's correct responses and L is the number of items on the test.

When the sum of the correct responses and the item calibrations (d_i) is known, an iterative procedure can be used to find the person measure (b_n) that will make the sum of the modeled probabilities most similar to the number of correct responses. One of the key features of the Rasch item-response model is its ability to place both persons and items on the same scale. It is possible to predict the odds of two individuals answering an item correctly based on knowledge of the relationship between the abilities of the two individuals. If one person has an ability measure double that of another person (as measured by b—the ability scale), then he or she has double the odds of answering the item correctly.

Equation 3 has several distinguishing characteristics:

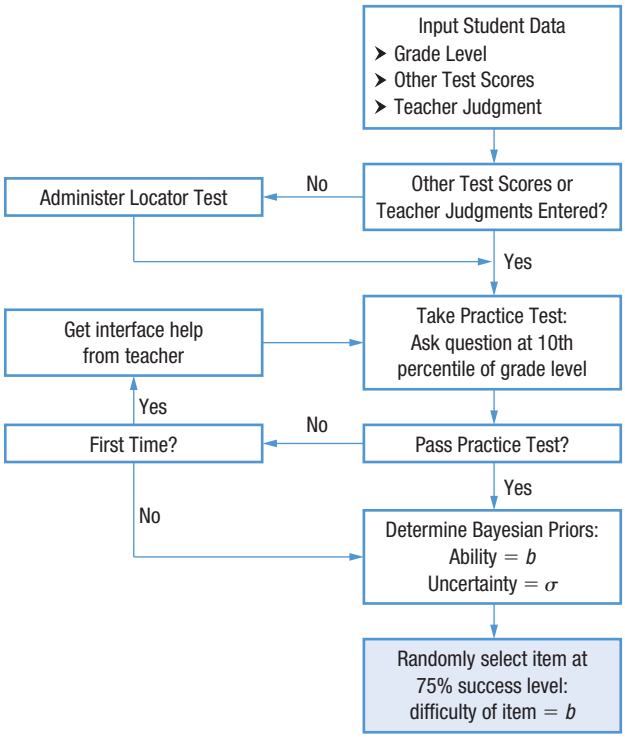
- The key terms from the definition of measurement are placed in a precise relationship to one another.
- The individual responses of a person to each item on an instrument are absent from the equation. The only piece of data that survives the act of observation is the "count correct" (O_p), thus confirming that the observation is "sufficient" for estimating the measure.

For any set of items the possible raw scores are known. When it is possible to know the item calibrations (either theoretically or empirically from field studies), the only parameter that must be estimated in Equation 3 is the measure that corresponds to each observable count correct. Thus, when the calibrations (d_i) are known, a correspondence table linking observation and measure can be constructed without reference to data from other individuals.

How does CAT testing work with the Reading Comprehension Assessment? As described earlier, the Reading Comprehension Assessment uses a three-phase approach to assess a student's level of reading ability: Start, Step, Stop. During test administration, the computer adapts the test continually according to the student's responses to the questions. The student *starts* the test; the test *steps* up or down according to the student's performance; and, when the computer has enough information about the student's reading level, the test *stops.*

The first phase, Start, determines the best point on the Lexile scale to begin testing the student. Figure 8 presents a flow chart of the "start" phase of the Reading Comprehension Assessment.

FIGURE 8. The "start" phase of the Reading Comprehension Assessment computer-adaptive algorithm.



Prior to testing, the teacher or administrator inputs information into the computer-adaptive algorithm that controls the administration of the test. The student's identification number and grade level must be input; prior standardized reading results (e.g., a Lexile measure from another reading assessment) and the teacher's estimate of the student's reading level may also be input. This information is used to determine the best starting point (Student Measure) for the student. The more information input into the algorithm, the better targeted the beginning of the test. Research has shown that well-targeted tests report less error in student scores than poorly targeted tests.

Within the Bayesian algorithm, initial Student Measures (ability [*b*]) are determined by the following information: grade level, prior Reading Comprehension Assessment test score, or teacher estimate of the student's reading level. If only *grade level* is entered, the student starts the Reading Comprehension Assessment with a Student Measure equal to the 50th percentile for his or her grade. If a *prior* Reading Comprehension Assessment *test score* and administration date are entered, then this Lexile measure is used as the Student Measure. The Student Measure is adjusted based on the amount of growth expected per month since the prior test was administered. The amount of growth expected in Lexile units per month is based on research by MetaMetrics, Inc., related to cross-sectional norms. If the teacher enters an *estimated reading level,* then the Lexile measure associated with each percentile for the grade is used as the Student Measure. Teachers can enter the following estimated reading levels: far below grade level (5th percentile), below grade level (25th percentile), on grade level (50th percentile), above grade level (75th percentile), and far above grade level (95th percentile).

Initial uncertainties (sigma [σ]) are determined by a prior Student Measure (if available), when the measure was collected, and the reliability of the measure. If a prior Student Measure is unavailable or if teacher estimation is the basis of the prior Student Measure, then maximum uncertainty (225L) is assumed. This value is based on prior research conducted by MetaMetrics, Inc. (2006a). If a prior Student Measure is available, then the elapsed time, measured in months, is used to prorate the maximum uncertainty associated with three years of elapsed time.

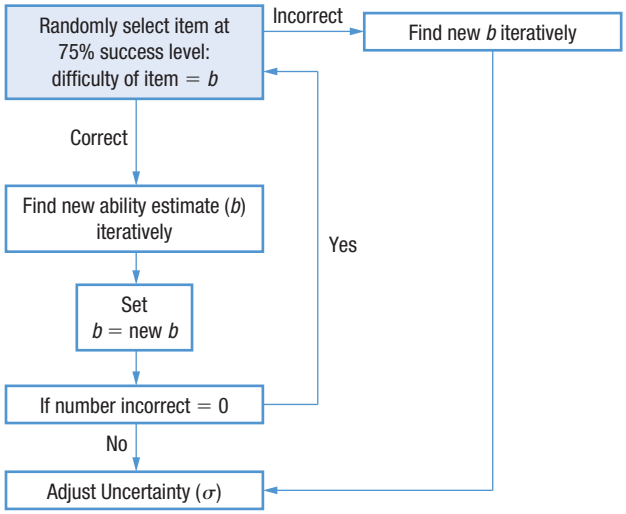
If the administration is the student's first time interacting with the Reading Comprehension Assessment, three practice items are presented. The practice items are selected at the 10th percentile for the grade level. The practice items are not counted in the student's score; their purpose is solely to familiarize the student with the embedded completion item format and the test's internal navigation.

If the student is enrolled in Grade 7 or above and no prior reading ability information (i.e., other test scores or teacher estimate) is provided, a short Locator Test is administered. The purpose of the Locator Test is to ensure that students who read significantly below grade level receive a valid Lexile measure from the first administration of the Reading Comprehension Assessment. When a student is initially mistargeted, it is difficult for the algorithm to produce a valid Lexile measure given the logistical parameters of the program. The items administered as the Locator Test are 500L below the "on grade level" (50th percentile) estimated reading level.

For subsequent administrations of the Reading Comprehension Assessment, the Reader Measure and uncertainty are the prior values adjusted for time. The Reader Measure is adjusted based on the amount of growth expected per month during the elapsed time. The elapsed time (measured in months) is used to prorate the maximum uncertainty associated with three years of elapsed time.

The second phase, *Step,* controls the selection of questions presented to the student. Figure 9 presents a flow chart of the "step" phase of the Reading Comprehension Assessment.

FIGURE 9. The "step" phase of the Reading Comprehension Assessment computer-adaptive algorithm.



If only the student's grade level was input during the first phase, then the student is presented with a question that has a Lexile measure at the 50th percentile for his or her grade. If more information about the student's reading ability was input during the first phase, then the student is presented with a question that is nearer his or her true ability. If the student responds correctly to the question, then he or she is presented with a question that is slightly more difficult. If the student responds incorrectly to the question, then he or she is presented with a question that is slightly less difficult. After the student responds to each question, his or her Reading Comprehension Assessment score (Lexile measure) is recomputed.

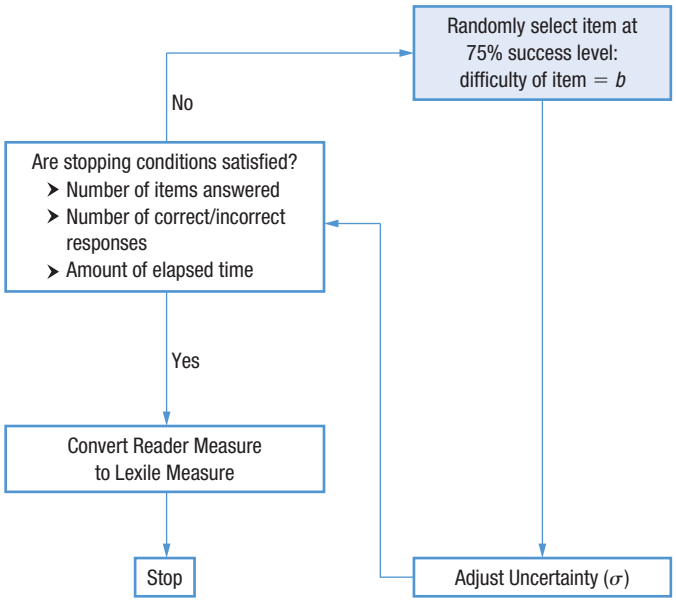
Questions are randomly selected from all possible items that are within 10L of the student's current Student Measure. If necessary, the range of items available for selection can be broadened to 50L. The frequency with which items appear is controlled by marking an item "Do Not Use" once it has been administered to a student. The item is then unavailable for selection in the next three test administrations.

If the student is in Grade 6 or above and his or her Lexile measure is below the specified minimum measure for the grade (15th percentile), then he or she is administered items from the Hi-Lo pool. This set of items has been identified from all items developed for the Reading Comprehension Assessment based on the following criteria:

(1) developmentally appropriate for middle and high school students (high interest) and (2) Lexile text measure between 200L and 1000L (low difficulty).

The final phase, *Stop,* controls the termination of the test. Figure 10 presents a flow chart of the "stop" phase of the Reading Comprehension Assessment.

FIGURE 10. The "stop" phase of the Reading Comprehension Assessment computer-adaptive algorithm.



Approximately 20 items are presented to every student. The exact number of items administered depends on how the student responds to the items as they are presented. In addition, how well-targeted the test is at its start affects the number of items presented to the student. Well-targeted tests begin with less measurement error and, subsequently, the student will be asked to respond to fewer items. After the student responds to each item, his or her Student Measure is calculated through an iterative process using the Rasch model.

The testing session ends when one of the following conditions is met:

- The student has responded to at least 20 items and has responded correctly to at least six items and incorrectly to at least three items.
- The student has responded to 30 items.
- The elapsed test administration time is at least 40 minutes and the student has responded to at least 10 items.

At this time the student's resulting Lexile measure and uncertainty are converted to Lexile units. Lexile measures are reported as a number followed by a capital "L." There is no space between the measure and the "L," and measures of 1,000 or greater are reported without a comma (e.g., 1050L). Within the Reading Comprehension Assessment, Lexile measures are reported to the nearest whole number. As with any test score, uncertainty in the form of measurement error is present. Lexile measures below 0L are reported as "BR" for "Beginning Reader."

The Reading Comprehension Assessment Algorithm Testing During Development

Feasibility Study. The Reading Comprehension Assessment was field tested with 879 students in Grades 3, 4, 5, and 7 from four schools in North Carolina and Florida. The schools were selected according to the following criteria: school location (urban versus rural), school size (small, medium, or large based on the number of students and staff), and availability of Macintosh computers within a laboratory setting.

- In *School 1* (suburban K–5), 72.1% of the students were white, 22.5% black, 4.8% Hispanic, 0.3% Asian, and 0.2% Native American. The computer lab was equipped with Power Mac G3s with 32 MB RAM. A total of 28 computers were in the lab arranged in four rows with a teacher station. There were also two video monitor displays in the lab.
- In *School 2* (rural K–5), 60.5% of the students were white, 29.7% black, 8.6% Hispanic, 0.7% Asian, and 0.5% Native American. Of the students sampled, 60% were male and 40% were female. The computer lab was equipped with Macintosh LC 580s.
- *School 3* (urban 6–8) was predominately white (91%), with 5% of the students classified as black, 2% of the students Hispanic, and 2% Asian. At the school, 17% of the students qualified for the free and reduced-price lunch program, 14% were classified as having a disability, 6% were classified as gifted, and 0.1% were classified as limited English proficient. Of the students sampled, 49% were male and 51% were female.

- *School 4* (urban K–5) was predominately white (86%), with 14% of the students classified as minority. Of the students sampled, 58% were male and 42% were female. At the school 46% of the students qualified for the free and reduced-price lunch program, 21% were classified as having a disability, 4% were classified as gifted, and 0.1% were classified as limited English proficient. Technology was integrated into all subjects and content areas, and the curriculum included a variety of hands-on activities and projects. The school had a school-wide computer network and at least one computer for every three students. Multimedia development stations with video laser and CD-ROM technology were also available.

The purpose of this phase of the study was to examine the algorithm and the software used to administer the computer-adaptive test. In addition, other reading test data was collected to examine the construct validity of the assessment.

Based on the results of the first administration in School 1, it was determined that the item selection routine was not selecting the optimal item each time. As a result, the calculation of the ability estimate was changed to occur after the administration of each item, and a specified minimum number of responses was required before the program terminated.

The Computer-Adaptive Test Survey was completed by 255 students (Grade 3, $N = 71$; Grade 5, $N = 184$). There were no significant differences by grade (Grade 3 versus Grade 5) or by school within grade (Grade 5: School 1 versus School 2) in the responses to any of the questions on the survey.

Question 1 asked students if they had understood how to take the computer-adaptive test. On a scale with 0 being "no" and 2 being "yes," the mean was 1.83. Students in Grades 3 and 5 responded the same way. This information was also confirmed in the written student comments and in the discussion at the end of the session. The program was easy to use and follow.

Question 2 asked students whether they used the mouse, the keyboard, or both to respond to the test. Of the 254 students responding to this question, 76% (194) used the mouse, 20% (52) used the keyboard, and 3% (8) used both the keyboard and the mouse. Several students commented that they liked the computer-adaptive test because it allowed them to use the mouse.

Question 7 asked students which testing format they preferred—paper-and-pencil, computer-adaptive, or both formats equally. Sixty-five percent of the sample preferred the computer-adaptive test format. There were no significant differences between the responses for students in Grade 3 compared to those in Grade 5. The results for each grade and the total sample are presented in Table 14.

TABLE 14. Student responses to Question 7: preferred test format.

Grade	Paper-and-Pencil Format	Computer-Adaptive Format	Both Formats Equally
3	9%	71%	20%
5	17%	62%	21%
Total	**15%**	**65%**	**21%**

Students offered a variety of reasons for preferring the computer-adaptive test format:

- "I liked that you don't have to turn the pages."
- "I liked that you didn't have to write."
- "I liked that you only had to point and click."
- "I liked the concept that you don't have a certain amount of questions to answer."
- "You don't write and don't have to worry about lead breaking or black stuff on your fingers."
- "I like working on computers."
- "I like the computer test because you do not have to erase."
- "Because you didn't have to circle the answer with a pencil and your hand won't hurt."

Of the 21% of students who liked both test formats equally, several students provided reasons:

- "They're about the same thing except on the computer your hand doesn't get tired."
- "On number 7 I put about the same because I like just the point that we don't have to write."

More Grade 5 students (17%) than Grade 3 students (9%) stated that they preferred the paper-and-pencil test format. This may be explained by the further development of test-taking strategies by the Grade 5 students. Their reasons for preferring the paper-and-pencil version generally dealt with features of the computer-adaptive test format—the ability to skip questions and review and change answers:

- "I liked the computer test, but I like paper-and-pencil because I can check over."
- "Because I can skip a question and look back on the story."

Four students stated that they preferred the paper-and-pencil format because of the computer environment:

- "I liked the paper-and-pencil test better because you don't have to stare at a screen with a horrible glare!"
- "Because it would be much easier for me because I didn't feel comfortable at a computer."
- "Because it is easier to read because my eyesight is bad."
- "I don't like reading on a computer."

Questions 4 and *5* on the survey dealt with the student's test-taking strategies—the ability to skip questions and to review and change responses. *Question 4* asked students whether they had skipped any of the questions on the computer-adaptive test. Seventy-three percent of the students skipped at least one item on the test. From the student's comments, this was one of the features of the computer-adaptive test that they really liked. Several students commented that they were not allowed enough passes. One student stated, "It's [the CAT] very easy to control and we can pass on the hard ones," and another student stated that, "I like the part where you could pass some [questions] where you did not understand."

Question 5 asked students whether they went back and changed answers when they took tests on paper. On a scale with 0 being "never" and 2 being "always," the mean was 0.98. According to many students' comments, not being able to go back and change answers was one of the features of the computer-adaptive test that they did not like.

Several students commented on the presentation of the text in the computer-adaptive test format:

- "I liked the way you answered the questions. I like the way it changes colors."
- "I didn't like the paragraphs changing size."
- "The words keep getting little then big."

Questions 3 and *6* dealt with the student's perceptions of the computer-adaptive test's difficulty. The information from these questions was not analyzed due to the redevelopment of the algorithm for selecting items.

When the Reading Comprehension Assessment was field tested with this sample of students in Grades 3, 4, 5, and 7 ($N = 879$) during the 1998–1999 school year, other measures of reading were collected. Tables 15 and 16 present the correlations between the Reading Comprehension Assessment and other measures of reading comprehension.

TABLE 15. Relationship between the Reading Comprehension Assessment (interactive) and the Reading Comprehension Assessment (print).

Grade	*N*	Correlation with *Reading Inventory*-Print
3	226	0.72
4	104	0.74
5	93	0.73
7	122	0.62
Total	**545**	**0.83**

TABLE 16. Relationship between the Reading Comprehension Assessment and other measures of reading comprehension.

Test	Grade	*N*	Correlation
North Carolina End-of-Grade Tests (NCEOG)	3 4	109 104	0.73 0.67
Pinellas Instructional Assessment Program (PIAP)	3	107	0.62
Comprehensive Test of Basic Skills (CTBS)	5 7	110 117	0.74 0.56

From the results it can be concluded that the Reading Comprehension Assessment measures a construct similar to that measured by other standardized tests designed to measure reading comprehension. The magnitude of the within-grade correlations with the Reading Comprehension Assessment-*Print* is close to that of the observed correlations for parallel test forms (i.e., alternate forms reliability), thus suggesting that the different tests are measuring the same construct. The NCEOG, PIAP, and CTBS tests consist of passages followed by traditional multiple-choice items, and the Reading Comprehension Assessment consists of embedded completion multiple-choice items. Given the differences in format, the limited range of scores (within grade), and the small sample sizes, the correlations suggest that the four assessments are measuring a similar construct.

Comparison of Reading Inventory 3.0 and Reading Inventory 4.0. The *Reading Inventory* Enterprise Edition of the suite of HMH technology products was built on *Industry-Standard Technology* that is smarter and faster and features SAM (Student Achievement Manager)—a robust management system. SAM provides district-wide data aggregation capabilities to help administrators meet AYP accountability requirements and provide teachers with data to differentiate instruction effectively.

Prior to the integration of version 4.0/Enterprise Edition (April and May 2005), a study was conducted to compare results from version 3.0 with those from version 4.0 (Scholastic, May 2005). A sample of 144 students in Grades 9–12 participated in the study. Each student was randomly assigned to one of four groups: (A) Test 1/v. 4.0; Test 2/v 3.0; (B) Test 1/v 3.0; Test 2/v4.0; (C) Test 1/v 3.0; Test 2/v 3.0; and (D) Test 1/v 4.0; Test 2/v 4.0. Each student's grade level was set and verified prior to testing. For students in groups (C) and (D), two accounts were established for each student to ensure that the starting criteria were the same for both test administrations. The final sample of students ($N = 122$) consisted of students who completed both assessments. Table 17 presents the summary results from the two testing groups that completed different versions of the *Reading Inventory*.

TABLE 17. Descriptive statistics for each test administration group in the comparison study, April and May 2005.

Test Group	Test 1		Test 2		Difference
	N	Mean (SD)	*N*	Mean (SD)	
A: Test 1/v 4.0; Test 2/v 3.0	32	1085.00 (179.13)	32	1103.34 (194.72)	−18.34
B: Test 1/v 3.0; Test 2/v 4.0	30	1114.83 (198.24)	30	1094.67 (232.51)	20.17

$p < .05$

The differences between the two versions of the test for each group were not significant (paired *t*-test) at the .05 level. It can be concluded that scores from versions 3.0 and 4.0 for groups (A) and (B) were not significantly different. A modest correlation of 0.69 was observed between the two sets of scores (version 3.0 and version 4.0). Given the small sample size ($N = 62$) that took the two different versions, the correlation meets expectations.

Locator Test Introduction Simulations. In 2005, with the move to *Reading Inventory* Enterprise Edition, Scholastic introduced the Locator Test. The purpose of the Locator Test is to ensure that students who read significantly below grade level (at grade level = 50th percentile) receive a valid Lexile measure from the first administration of the Reading Comprehension Assessment. Two studies were conducted to examine whether the Locator Test was serving the purpose for which it was designed.

Study 1. The first study was conducted in September 2005 and consisted of simulating the responses of approximately 90 test administrations "by hand." The results showed that students who failed the Locator Test could get BR scores (Scholastic, 2006b, p.1).

Study 2. The second study was conducted in 2006 and consisted of the simulation of 6,900 students under five different test conditions. Each simulated student took all five tests (three tests included the Locator Test and two excluded it).

The first simulation tested whether students who perform as well on the Locator Test as they perform on the rest of the Reading Comprehension Assessment can expect to receive higher or lower scores (Trial 1) than if they never receive the Locator Test (Trial 4). A total of 4,250 simulated students participated in this study, and a correlation of .96 was observed between the two test scores (with and without the Locator Test). The results showed that performance on the Locator Test did not affect Reading Comprehension Assessment scores for students who had reading abilities above BR ($N = 4{,}150$; Wilcoxson Rank Sum Test = 1.7841e07; $p = .0478$). In addition, the proportion of students who scored BR from each administration was examined. As expected, the proportion of students who scored BR without the Locator Test was 12.17% (840 out of 6,900) compared to 22.16% (1,529 out of 6,900) who scored BR with the Locator Test. The results confirmed the hypothesis that the Locator Test allows students to start the Reading Comprehension Assessment at a much lower Reader Measure and, thus, descend to the BR level with more reliability.

The third simulation tested whether students who failed the Locator Test (Trial 3) received basically the same score as when they had a prior Student Measure 500L below grade level and were administered the Reading Comprehension Assessment without the Locator Test (Trial 5). The results showed that failing the Locator Test produced results similar to inputting a "below basic" estimated reading level ($N = 6{,}900$; Wilcoxson Rank Sum Test = 4.7582e07; $p = .8923$).

Reliability

Reliability

Internal Consistency Reliability Coefficients

Content-sampling error was estimated by calculating internal consistency reliability coefficients (coefficient alpha) for Foundational Reading Assessment scores. These reliability coefficients are presented in Table 18.

TABLE 18. Internal consistency reliability coefficients (coefficient alpha) for Foundational Reading Assessment scores overall and by grade.

COEFFICIENT ALPHA				
	Overall	**K**	**1**	**2**
Total Accuracy	.855	.845	.819	.837
Total Fluency	.935	.904	.930	.918
Phonological Awareness Accuracy	.749	.597	.718	.607
Phonological Awareness Fluency	.764	.680	.745	.717
Word-Level Reading Accuracy	.842	.829	.805	.815
Word-Level Reading Fluency	.935	.903	.929	.916
Word-Level Reading (w/o Letters) Accuracy	.841	.815	.800	.817
Word-Level Reading (w/o Letters) Fluency	.931	.924	.927	.908
Letter Names and Sight Words Accuracy	.833	.721	.743	.716
Letter Names and Sight Words Fluency	.886	.759	.832	.826
Letter Sounds and Nonwords Accuracy	.805	.793	.708	.774
Letter Sounds and Nonwords Fluency	.912	.837	.902	.892
Letter Names Accuracy	.787	.790	.611	.521
Letter Names Fluency	.781	.739	.663	.663
Sight Words Accuracy	.816	.571	.733	.724
Sight Words Fluency	.878	.725	.827	.815
Letter Sounds Accuracy	.820	.752	.705	.767
Letter Sounds Fluency	.797	.671	.697	.705
Nonwords Accuracy	.791	.690	.706	.776
Nonwords Fluency	.908	.850	.904	.887

Note. Word-Level Reading = Letter Names, Sight Words, Letter Sounds, Nonwords.

To be useful, a piece of information should be reliable—stable, consistent, and dependable. In reality, all test scores include some measure of error (or level of uncertainty). This uncertainty in the measurement process is related to three factors: (1) the statistical model used to compute the score, (2) the questions used to determine the score, and (3) the condition of the test taker when the questions used to determine the score were administered. Once the level of uncertainty in a test score is known, then it can be taken into account when the test results are used. Reliability, or the consistency of scores obtained from an assessment, is a major consideration in evaluating any assessment procedure.

Standard Error of Measurement

Uncertainty and Standard Error of Measurement. There is always some uncertainty about a student's true score because of the measurement error associated with test unreliability. This uncertainty is known as the standard error of measurement (SEM). The magnitude of the SEM of an individual student's score depends on the following characteristics of the test:

- The number of test items—smaller standard errors are associated with longer tests.
- The quality of the test items—in general, smaller standard errors are associated with highly discriminating items for which correct answers cannot be obtained by guessing.
- The match between item difficulty and student ability—smaller standard errors are associated with tests composed of items with difficulties approximately equal to the ability of the student (targeted tests) (Hambleton, Swaminathan, & Rogers, 1991).

The Foundational Reading Assessment: Standard Error of Measurement

The SEM is calculated by multiplying the standard deviation of a test score by the square root of 1 minus the reliability of the test score. SEMs for the Foundational Reading Assessment Scores with sufficient reliability for making decisions are presented in Table 19.

TABLE 19. Standard errors of measurement (SEM) for selected Foundational Reading Assessment scores, by grade.

	SEM		
Foundational Reading Assessment Score	**Kindergarten**	**First Grade**	**Second Grade**
Total Fluency	3	4	4
Word-Level Reading Fluency	3	4	4
Word-Level Reading (w/o Letters) Fluency	2	3	3

SEM values allow us to put confidence intervals around Foundational Reading Assessment Scores. The 95% confidence interval is twice the SEM above and below the score. This means that the 95% confidence interval for a total fluency score of 20 obtained by a student in kindergarten, for example, is 14 to 26.

The reliability analyses indicate that the Foundational Reading Assessment Scores of Total Fluency, Word-Level Reading Fluency, and Word-Level Reading Fluency Without Letters meet the highest standard of reliability. The standard error of measurement (SEM) for the Foundational Reading Assessment ranges from 2 to 4. This corresponds to 95% confidence intervals of plus or minus 4 to plus or minus 8.

The Reading Comprehension Assessment: Standard Error of Measurement

The Reading Comprehension Assessment was developed using the Rasch one-parameter item-response theory model to relate a reader's ability to the difficulty of the items. There is a unique amount of measurement error due to model misspecification (violation of model assumptions) associated with each score on the Reading Comprehension Assessment. The computer algorithm that controls the administration of the assessment uses a Bayesian procedure to estimate each student's reading ability. This procedure uses prior information about students to control the selection of questions and the recalculation of each student's reading ability after responding to each question.

Compared to a fixed-item test where all students answer the same questions, a computer-adaptive test produces a different test for every student. When students take a computer-adaptive test, they all receive approximately the same raw score or number of items correct. This occurs because all students are answering questions that are targeted for their unique ability—not questions that are too easy or too hard. Because each student takes a unique test, the error associated with any one score or student is also unique.

The initial uncertainty for a Reading Comprehension Assessment score is 225L (within-grade standard deviation from previous research conducted by MetaMetrics, Inc.). When a student retests with the Reading Comprehension Assessment, the uncertainty of his or her score is the uncertainty that resulted from the previous assessment adjusted for the time elapsed between administrations. An assumption is made that after three years without a test, the student's ability should again be measured at maximum uncertainty. Average SEMs are presented in Table 20. These values can be used as a general "rule of thumb" when reviewing Reading Comprehension Assessment results. It bears repeating that *because each student takes a unique test and the results rely partly on prior information, the error associated with any one score or student is also unique.*

TABLE 20. Mean SEM on the Reading Comprehension Assessment by extent of prior knowledge.

Number of Items	SEM Grade Level Known	SEM Grade and Reading Level Known
15	104L	58L
16	102L	57L
17	99L	57L
18	96L	57L
19	93L	57L
20	91L	56L
21	89L	56L
22	87L	55L
23	86L	54L
24	84L	54L

As can be seen from the information in Table 20, when the test is well targeted (grade level and prior reading level of the student are known), the student can respond to fewer test questions and not increase the error associated with the measurement process. When only the grade level of the student is known, the more questions the student responds to, the less error in the score associated with the measurement process.

Sources of Measurement Error—Text

The Reading Comprehension Assessment is a theory-referenced measurement system for reading comprehension. Internal consistency and other traditional indices of test quality are not critical considerations (Green, Bock, Humphreys, Linn, & Reckase, 1984), although marginal reliability, a variant of traditional reliability estimates, is discussed later in this section, as are alternate form and test-retest reliability estimates. What matters is how well individual and group performances conform to theoretical expectations. The Lexile Framework states an invariant and absolute requirement that the performance of items and test takers must match.

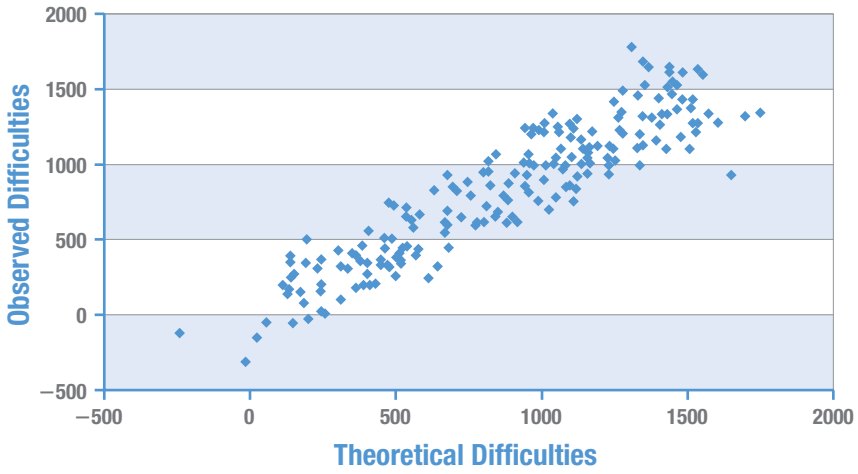
Measurement is the process of converting observations into quantities via theory. There are many sources of error in the measurement process: the model used to relate observed measurements to theoretical ones, the method used to determine measurements, and the moment when measurements are made.

To determine a Lexile measure for a text, the standard procedure is to process the entire text. All pages in the work are concatenated into an electronic file that is processed by a software package called the Lexile Analyzer (developed by MetaMetrics, Inc.). The analyzer "slices" the text file into as many 125-word passages as possible, analyzes the set of slices, and then calibrates each slice in terms of the logit metric. That set of calibrations is then processed to determine the Lexile measure corresponding to a 75% comprehension rate. The analyzer uses the slice calibrations as test item calibrations and then solves for the measure corresponding to a raw score of 75% (e.g., 30 out of 40 correct, as if the slices were test items). Obviously, the measure corresponding to a raw score of 75% on *Goodnight Moon* (300L) slices would be lower than the measure corresponding to a comparable raw score on *USA Today* (1200L) slices. The Lexile Analyzer automates this process, but what "certainty" can be attached to each text measure?

Using the bootstrap procedure to examine error due to the text samples, the above analysis could be repeated. The result would be an identical text measure to the first because there is no sampling error when a complete text is calibrated.

There is, however, another source of error that increases the uncertainty about where a text is located on the Lexile Framework Map. The Lexile Theory is imperfect in its calibration of the difficulty of individual text slices. To examine this source of error, 200 items that had been previously calibrated and shown to fit the model were administered to 3,026 students in Grades 2–12 in a large urban school district. The sample of students was socioeconomically and ethnically diverse. For each item the observed item difficulty calibrated from the Rasch model was compared with the theoretical item difficulty calibrated from the regression equation used to calibrate texts. A scatter plot of the data is presented in Figure 11.

FIGURE 11. Scatter plot between observed item difficulty and theoretical item difficulty.



The correlation between the observed and the theoretical calibrations for the 200 items was .92, and the root mean square error was 178L. Therefore, for an individual slice of text the measurement error is 178L.

The standard error of measurement associated with a text is a function of the error associated with one slice of text (178L) and the number of slices that are calibrated from a text. Very short books have larger uncertainties than longer books. A book with only four slices would have an uncertainty of 89L, whereas a longer book such as *War and Peace* (4,082 slices of text) would have an uncertainty of only 3L (Table 21).

TABLE 21. Standard errors for selected values of the length of the text.

Title	Number of Slices	Text Measure	Standard Error of Text
The Stories Julian Tells	46	520L	26L
Bunnicula	102	710L	18L
The Pizza Mystery	137	620L	15L
Meditations of First Philosophy	206	1720L	12L
Metaphysics of Morals	209	1620L	12L
Adventures of Pinocchio	294	780L	10L
The Red Badge of Courage	348	900L	10L
The Scarlet Letter	597	1420L	7L
Pride and Prejudice	904	1100L	6L
The Decameron	2,431	1510L	4L
War and Peace	4,082	1200L	3L

Study 2. A second study was conducted by Stenner, Burdick, Sanford, and Burdick (2006) during 2002 to examine ensemble differences across items. An ensemble consists of all of the items that could be developed from a selected piece of text. The theoretical Lexile measure of a piece of text is the mean theoretical difficulty of all items associated with the text. Stenner and his colleagues state that the "Lexile Theory replaces statements about individual items with statements about ensembles. The ensemble interpretation enables the elimination of irrelevant details. The extra-theoretical details are taken into account jointly, not individually, and, via averaging, are removed from the data text explained by the theory" (p. 314). The result is that when making text-dependent generalizations, text readability can be measured with high accuracy and the uncertainty in expected comprehension is largely due to the unreliability in reader measures.

Participants. Participants in this study were students from four school districts in a large southwestern state. These students were participating in a larger study that was designed to assess reading comprehension with the Lexile scale. The total sample included 1,186 Grade 3 students, 893 Grade 5 students, and 1,531 Grade 8 students. The mean tested abilities of the three samples were similar to the mean tested abilities of all students in each grade on the state reading assessment. Though 3,610 students participated in the study, the data records for only 2,867 of these students were used for determining the ensemble item difficulties presented in this paper. The students were administered one of four forms at each grade level. The reduction in sample size is because one of the four forms was created using the same ensemble items as another form. For consistency of sample size across forms, the data records from this fourth form were not included in the ensemble study.

Instrument. Thirty text passages were response illustrated by three different item-writing teams, resulting in three items nested within each of 30 passages for a total of 90 items. All three teams employed a similar item-writing protocol. The ensemble items were spiraled into test forms at the grade level (3, 5, or 8) that most closely corresponded with the item's theoretical calibration.

Winsteps (Wright & Linacre, 2003) was used to estimate item difficulties for the 90 ensemble study items. Of primary interest in this study was the correspondence between theoretical text calibrations and ensemble means and the consequences that theory misspecification holds for text measure standard errors.

Results. Table 22 presents the ensemble study data in which three independent teams wrote one item for each of 30 passages to make a total of 90 items. Observed ensemble means taken over the three ensemble item difficulties for each passage are given along with an estimate of the within ensemble standard deviation for each passage.

TABLE 22. Analysis of 30 item ensembles providing an estimate of the theory misspecification error.

Item Number	Theory (T)	Team A	Team B	Team C	Mean[a] (O)	SD[b]	Within Ensemble Variance	T-O
1	400L	456	553	303	437	126	15,909	−37
2	430L	269	632	704	535	234	54,523	−105
3	460L	306	407	483	399	88	7,832	61
4	490L	553	508	670	577	84	6,993	−87
11	510L	267	602	468	446	169	28,413	64
5	540L	747	825	654	742	86	7,332	−202
6	569L	909	657	582	716	172	29,424	−147
7	580L	594	683	807	695	107	11,386	−115
8	620L	897	805	497	733	209	43,808	−113
9	720L	584	850	731	722	133	17,811	−2
12	720L	953	587	774	771	183	33,386	−51
13	745L	791	972	490	751	244	59,354	−6
14	770L	855	1017	958	944	82	6,717	−174
16	770L	1077	1095	893	1022	112	12,446	−252
15	790L	866	557	553	659	180	32,327	131
21	812L	902	1133	715	917	209	43,753	−105
10	820L	967	740	675	794	153	23,445	26
17	850L	747	864	674	762	96	9,257	88
22	866L	819	809	780	803	20	419	63
18	870L	974	1197	870	1014	167	28,007	−144
19	880L	1093	733	692	839	221	48,739	41
23	940L	945	1057	965	989	60	3,546	−49
24	960L	1124	1205	1170	1166	41	1,653	−206
25	1010L	926	1172	899	999	151	22,733	11
20	1020L	888	1372	863	1041	287	82,429	−21
26	1020L	1260	987	881	1043	196	38,397	−23
27	1040L	1503	1361	1239	1368	132	17,536	−328
28	1060L	1109	1091	981	1061	69	4,785	−1
29	1150L	1014	1104	1055	1058	45	2,029	92
30	1210L	1275	1291	1014	1193	156	24,204	17

Total MSE = Average of $(T\text{-}O)^2$ = 12022; Pooled within variance for ensembles = 7984; Remaining between ensemble variance = 4038; Theory misspecification error = 64L

Barlett's test for homogeneity of variance produced an approximate chi-square statistic of 24.6 on 29 degrees of freedom and sustained the null hypothesis that the variances are equal across ensembles.

Note. All data is reported in Lexile measures.

a. Mean (O) is the observed ensemble mean.

b. SD is the standard deviation within ensemble.

The difference between passage text calibration and observed ensemble mean is provided in the last column. The RMSE from regressing observed ensemble means on text calibrations is 110L. Figures 12a and 12b show plots of observed ensemble means compared to theoretical text calibrations.

FIGURE 12A. Plot of observed ensemble means and theoretical calibrations (RMSE = 111L).

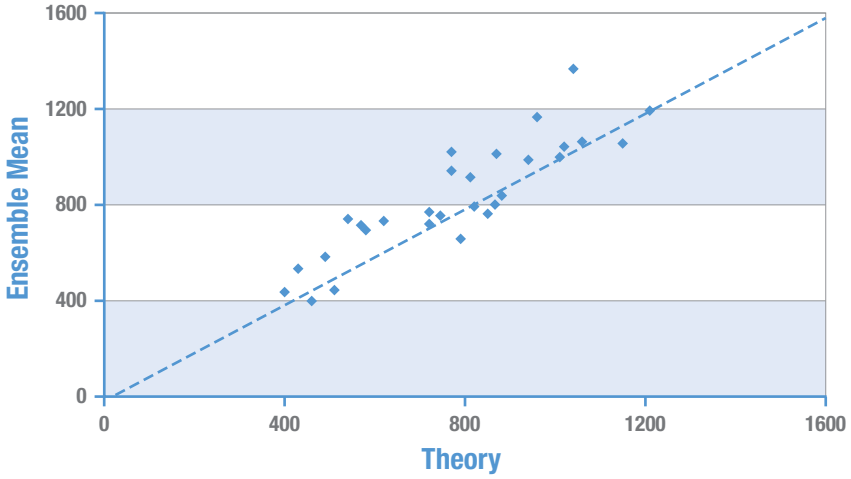
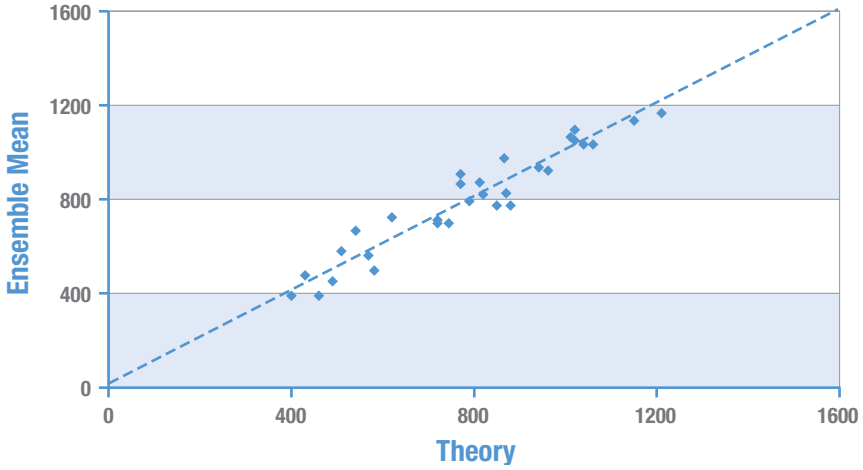


FIGURE 12B. Plot of simulated "true" ensemble means and theoretical calibrations (RMSE = 64L).



Note that some of the deviations about the identity line are because ensemble means are poorly estimated given that each mean is based on only three items. The bottom panel in Figure 12b depicts simulated data when an error term [distributed ~ $N(0, \sigma = 64\text{L})$] is added to each theoretical value. Contrasting the two plots in Figures 12a and 12b provides a visual depiction of the difference between regressing observed ensemble means on theory and regressing "true" ensemble means on theory. An estimate of the RMSE when "true" ensemble means are regressed on the Lexile Theory is 64L ($\sqrt{110^2 - 89^2} = \sqrt{4{,}038} = 63.54$). This is the average error at the passage level when predicting "true" ensemble means from the Lexile Theory.

Since the RMSE equal to 64L applies to the expected error at the passage/slice level, a text made up of n_i slices would have an expected error of 64 $\div \sqrt{n_i}$. Thus, a short periodical article of 500 words ($n_i = 4$) would have a SEM of 32L (64 $\div \sqrt{4}$), whereas a much longer text like the novel *Harry Potter: Chamber of Secrets* (880L, Rowling, 2001) would have a SEM of 2L (64 $\div \sqrt{900}$). Table 22 contrasts the SEMs computed using the old method with SEMs computed using the Lexile Framework for several books across a broad range of Lexile measures.

TABLE 23. Old method text readabilities, resampled SEMs, and new SEMs for selected books.

Book	Number of Slices	Lexile Measure	Resampled Old SEM[a]	New SEM
The Boy Who Drank Too Much	257	447L	102	4
Leroy and the Old Man	309	647L	119	4
Angela and the Broken Heart	157	555L	118	5
The Horse of Her Dreams	277	768L	126	4
Little House by Boston Bay	235	852L	126	4
Marsh Cat	235	954L	125	4
The Riddle of the Rosetta Stone	49	1063L	70	9
John Tyler	223	1151L	89	4
A Clockwork Orange	419	1260L	268	3
Geometry and the Visual Arts	481	1369L	140	3
The Patriot Chiefs	790	1446L	139	2
Traitors	895	1533L	140	2

a. Three slices selected for each replicate: one slice from the first third of the book, one from the middle third, and one from the last third. Resampled 1,000 times. SEM = SD of the resampled distribution.

As can be seen in Table 23, the uncertainty associated with the measurement of the reading demand of the text is small.

Sources of Measurement Error—Item Writers

Another source of uncertainty in a test measure is due to the writers who develop the test items. Item writers are trained to develop items according to a set of procedures, but item writers are individuals and therefore subject to differences in behavior. General objectivity requires that the origin and unit of measure be maintained independently of the instant and particulars of the measurement process (Stenner & Burdick, 1997). The Reading Comprehension Assessment purports to yield generally objective measures of reader performance.

Prior to working on the Reading Comprehension Assessment, five item writers attended a four-hour training session that included an introduction to the Lexile Framework, rules for writing native-Lexile-format items, practice in writing items, and instruction in how to use the Lexile Analyzer software to calibrate test items. Each item writer was instructed to write 60 items uniformly distributed over the range from 900L to 1300L. Items were edited for rule compliance by two trained item writers.

The resulting 300 items were organized into five test forms of 60 items each. Each item writer contributed 12 items to each form. Items on a form were ordered from lowest calibration to highest. The five forms were administered in random order over five days to seven students (two sixth graders and five seventh graders). Each student responded to all 300 items. Raw score performances were converted via the Rasch model to Lexile measures using the theoretical calibrations provided by the Lexile Analyzer.

Table 24 displays the students' scores by item writer. A part measure is the Lexile measure for the student on the cross-referenced writer's items ($N = 60$). Part-measure resampled SEMs describe expected variability in student performances when generalizing over items and days.

TABLE 24. Lexile measures and standard errors across item writers.

Writer	Student						
	A	B	C	D	E	F	G
1	937 (58)	964 (74)	1146 (105)	1375 (70)	1204 (73)	1128 (93)	1226 (155)
2	1000 (114)	927 (85)	1156 (72)	1249 (76)	1047 (118)	1156 (83)	1136 (129)
3	1002 (94)	1078 (72)	1095 (86)	1323 (127)	1189 (90)	1262 (90)	1236 (111)
4	952 (74)	1086 (71)	1251 (108)	1451 (126)	1280 (115)	1312 (95)	1251 (114)
5	973 (77)	945 (88)	1163 (82)	1452 (85)	1163 (77)	1223 (71)	1109 (116)
Across Items & Days	972 (13)	1000 (34)	1162 (25)	1370 (39)	1176 (38)	1216 (42)	1192 (29)
Across IWs, Items, Days	972 (48)	998 (46)	1158 (50)	1360 (91)	1170 (51)	1209 (54)	1187 (47)

Two methods were used to determine each student's Lexile measure: (1) across all 300 items and (2) by item writer. By employing two methods, different aspects of uncertainty could be examined. Using the first method (level determined by an analysis of all 300 items), resampling using the bootstrap procedure accounted for uncertainty across item writers, items, and occasions (days). The reading comprehension abilities of the students ranged from 972L to 1360L. Since the items were targeted at 900L to 1300L, only student D was mistargeted. Mistargeting resulted in the SEM of the student's score being almost twice that of the other students measured.

Using the second method (level determined by analysis of the part scores of the items written by each item writer), resampling using the bootstrap procedure accounted for uncertainty across days and items. Error due to differences in occasions and items accounted for about two-thirds of the error in the student measures.

The box-and-whisker plots in Figure 13 display each student's results, with the box representing the 90% confidence interval. The long line through each graph shows where the student's overall measure falls in relation to the part scores computed separately for each item writer. For each student, his or her measure line passes through every box on the plot.

FIGURE 13. Examination of item-writer error across items and occasions.

By chance alone at least three graphs would show lines that did not pass through a box. Thus, the item writer's effect on the student's measure is negligible. Item writer is a proxy for (1) mode of the text—whether the writer chose a narrative or expository passage, (2) source of the text—no two writers wrote items for the same passage, and (3) style variation—how writers created embedded completion items. A combination of item-writing specification and the Lexile Analyzer's calibration of items resulted in reproducible reader measures based on theory alone.

General objectivity requires that the origin and unit of measure be maintained independently of the instant and particulars of the measurement process. This study demonstrates that the Reading Comprehension Assessment produces reproducible measures of reader performance independently of item author, source of text, and occasion of measurement.

The Lexile unit is specified through the calibration equations that operationalize the construct theory. These equations are used to define and maintain the unit of measurement independently of the method and instant of measurement. A Lexile unit transcends the instrument and thereby achieves the status of a quantity. Without this transcendent quality, units remain local and dependent on particular instruments and samples for their absolute expression (Stenner, 1994).

Sources of Measurement Error—Reader

Resampling of reader performance implies a different set of items (method) on a different occasion (moment)—method and moment are random facets and are expected to vary with each replication of the measurement process. With this definition of a replication there is nothing special about one set of items compared with another set, nor is there anything special about one Tuesday morning compared to another. Any calibrated set of items given on any day within a two-week period is considered interchangeable with any other set of items given on another day (method and moment). The interchangeability of the item sets suggests there is no a priori basis for believing that one particular method-moment combination will yield a higher or lower measure than any other. That is not to say that the resulting measures are expected to be the same. On the contrary, they are expected to be different. It is unknown which method-moment combination will prove more difficult and which more easy. The anticipated variance among replications due to method-moment combinations and their interactions is error.

A better understanding of how these sources of error come about can be gained by describing some of the measurement and behavior factors that may vary from administration to administration. Suppose that most of the Reading Comprehension Assessment items that Sally responds to are sampled from books in the Baby-Sitter's Club series (by Ann M. Martin), which is Sally's favorite series. When Sally is measured again, the items are sampled from less familiar texts. The differences in Lexile measures resulting from highly familiar and unfamiliar texts would be in error. The items on each level of the Reading Comprehension Assessment were selected to minimize this source of error. It was specified during item development that no more than two items could be developed from a single source or series.

Characteristics of the moment and context of measurement can contribute to variation in replicate measures. Suppose, unknown to the test developer, scores increase with each replication due to practice effects. This "occasion main effect" also would be treated as error. Again, suppose Sally is fed breakfast and rides the bus on Tuesdays and Thursdays, but on Mondays, Wednesdays, and Fridays her parent has early business meetings, and Sally gets no breakfast and must walk one mile to school. Some of the test administrations occur on what Sally calls her "good days" and some occur on "bad days." Variation in her reading performance due to these context factors contributes to error. (For more information related to why scores change, see the paper entitled "Why Do Scores Change?" by Gary L. Williamson (2004) located at www.lexile.com.)

A viable approach to attaching uncertainty to a reader's measure is to resample the item-response record (i.e., simulating what would happen if the reader were actually assessed again). Suppose eight-year-old José takes two 40-item Reading Comprehension Assessment tests one week apart. Occasions (the two different days) and the 40 items nested within each occasion can be independently resampled (two-stage resampling), and the resulting two measures averaged for each replicate. One thousand replications would result in a distribution of replicate measures. The standard deviation of this distribution is the resampled SEM, and it describes uncertainty in José's reading measure by treating methods (items), moments (occasion and context), and their interactions as error. Furthermore, in computing José's reading measure and the uncertainty in that measure, he is treated as an individual without reference to the performance of other students. In general, on the Reading Comprehension Assessment, typical reader measure error across items (method) and days (moment) is 70L (Stenner, 1996).

Reading Comprehension Assessment Marginal Reliability. For a computer-adaptive test where there are no "fixed forms" (established test forms) and the items and tests are calibrated using item-response theory, the traditional measures of reliability are not appropriate (Green, Bock, Humphreys, Linn, & Reckase, 1984). Fortunately, item-response theory provides an index of reliability for an entire test that does not require all children to be administered the same exact items. The marginal reliability is computed by determining the proportion of test performance that is not due to error (i.e., the true score). Technically, the marginal reliability is computed by subtracting the total variability in estimated ability by an error term, and dividing this difference by the total estimated ability. As with traditional reliability (e.g., Cronbach alpha), the marginal reliability is a coefficient between 0 and 1 that measures the proportion of the instrument score that is attributed to the actual ability levels of the participants rather than aberrant "noise." Thus, a marginal reliability that exceeds 0.80 provides evidence that the scores on a reading test accurately separate or discriminate among a test taker's reading ability.

Within Winsteps item analysis program (Linacre, 2010), the marginal reliability is calculated as the model reliability. The model reliability estimate describes the upper bound of the "true" reliability of person ordering and is dependent on sample ability variance, length of the test, number of categories per item, and sample-item targeting.

In 2013, a study was conducted to examine the marginal reliability of Reading Comprehension Assessment test results (MetaMetrics, 2013b). The Reading Comprehension Assessment was administered to 3,488 students in Grades 2–12 in a large, midwestern, urban district (San Antonio Independent School District, Texas). The sample consisted of 2,818 students (80.8%) classified as Hispanic (district: 91.3%) and 3,010 students (86.3%) classified as economically disadvantaged (district: 92.8%). The data was analyzed using Winsteps and the marginal (model) reliability is reported in Table 25.

TABLE 25. Reading Comprehension Assessment marginal reliability estimate.

	Grades	Number of Students (*N*)	Number of *Reading Inventory* Administrations (*N*)	Number of *Reading Inventory* Items Tested (*N*)	Marginal Reliability
All Students	2–12	3,488	11,125	4,633	0.94

Based upon these marginal reliability estimates, the Reading Comprehension Assessment is able to consistently order students and these estimates provide an upper bound for all other estimates of the reliability of the Reading Comprehension Assessment. The marginal reliability estimate does not include "variability due to short-run random variation of the trait being measured or situational variance in the testing conditions" (Green, Bock, Humphreys, Linn, & Reckase, 1984, p. 353). In order to examine variation in test scores due to these sources of error, empirical studies need to be conducted.

Reader Measure Consistency. Alternate-form reliability examines the extent to which two equivalent forms of an assessment yield the same results (i.e., students' scores have the same rank order on both tests). Test-retest reliability examines the extent to which two administrations of the same test yield similar results. When taken together, alternate-form reliability and test-retest reliability are estimates of reader measure consistency. Two studies have examined the consistency of reader measures. If decisions about individuals are to be made on the basis of assessment data (for example, placement or instructional program decisions), then the assessment results should exhibit a reliability coefficient of at least 0.85.

Study 1. During January 2000, a study was conducted to compare the Reading Comprehension Assessment with scores from the STAR assessment (School Renaissance Institute). The Reading Comprehension Assessment was administered twice to 104 students in Grades 1–11 over a two-week period. The correlation between the two Lexile measures, an estimate of the reader measure consistency, was 0.886.

Study 2. In a large urban school district, the Reading Comprehension Assessment was administered to all students in Grades 2–10. Table 26 shows the reader consistency estimates for each grade level and across all grades over a four-month period. The data is from the first and second Reading Comprehension Assessment administrations during the 2004–2005 school year.

TABLE 26. Reading Comprehension Assessment reader consistency estimates over a four-month period, by grade.

Grade	*N*	Reader Consistency Correlation
3	1,241	0.829
4	7,236	0.832
5	8,253	0.854
6	6,339	0.848
7	3,783	0.860
8	3,581	0.877
9	2,694	0.853
10	632	0.901
Total	**33,759**	**0.894**

Forecasted Comprehension Error for the Reading Comprehension Assessment

The difference between a text measure and a reader measure can be used to forecast the reader's comprehension of the text. If a 1200L reader reads *USA Today* (1200L), the Lexile Framework forecasts 75% comprehension. This forecast means that if a 1200L reader responds to 100 items developed from *USA Today,* the number correct is estimated to be 75, or 75% of the items administered. The same 1200L reader is forecast to have 50% comprehension of senior-level college text (1450L) and 90% comprehension of *The Secret Garden* (950L). How much error is present in such a forecast? That is, if the forecast were recalculated, what kind of variability in the comprehension rate would be expected?

The comprehension rate is determined by the relationship between the reader measure and the text measure. Consequently, error variation in the comprehension rate derives from error variation in those two quantities. Using resampling theory, a small amount of variation in the text measure and considerably more variation in the reader measure will be expected. The result of resampling is a new text measure and a new reader measure, which combine to forecast a new comprehension rate. Thus, errors in reader measure and text measure combine to create variability in the replicated comprehension rate. Unlike text and reader error, comprehension rate error is not symmetrical about the forecasted comprehension rate.

It is possible to determine a confidence interval for the forecasted comprehension rate. Suppose a 1000L reader measured with 71L of error reads a 1000L text measured with 30L of error. The error associated with the difference between the reader measure and the text measure (0L) is 77L (Stenner & Burdick, 1997). Referring to Table 27, the 90% confidence interval for a 75% forecasted comprehension rate is 63% to 84% comprehension (round the SED of 77L to 80L for nearest tabled value).

TABLE 27. Confidence intervals (90%) for various combinations of comprehension rates and standard error differences (SED) between reader and text measures.

Reader—Text (in Lexile Measures)	Forecasted Comprehension Rate	SED 40	SED 60	SED 80	SED 100	SED 120
–250	50%	43–57	39–61	36–64	33–67	30–70
–225	53%	46–60	42–63	38–67	35–70	32–73
–200	55%	48–62	45–66	41–69	38–72	34–75
–175	58%	51–65	47–68	44–71	40–74	37–77
–150	61%	54–67	50–71	47–73	43–76	39–79
–125	63%	56–70	53–73	49–76	46–78	42–81
–100	66%	59–72	56–75	52–78	48–80	45–82
–75	68%	62–74	58–77	55–79	51–82	48–84
–50	71%	64–76	61–79	57–81	54–83	50–85
–25	73%	67–78	64–81	60–83	57–85	53–87
0	75%	69–80	66–82	63–84	59–86	56–88
25	77%	72–82	68–84	65–86	62–87	58–89
50	79%	74–83	71–85	68–87	64–89	61–90
75	81%	76–85	73–87	70–88	67–90	64–91
100	82%	78–86	75–88	72–89	69–91	66–92
125	84%	80–87	77–89	74–90	72–91	69–93
150	85%	81–89	79–90	77–91	74–92	71–93
175	87%	83–90	81–91	78–92	76–93	73–94
200	88%	84–91	82–92	80–93	78–94	76–95
225	89%	86–92	84–93	82–94	80–94	77–95
250	90%	87–92	85–93	83–94	81–95	79–96

Validity

Validity

Validity is the "extent to which a test measures what its authors or users claim it measures; specifically, test validity concerns the appropriateness of inferences that can be made on the basis of test results" (Salvia & Ysseldyke, 1998). The 1999 *Standards for Educational and Psychological Testing* (America Educational Research Association, American Psychological Association, and National Council on Measurement in Education) state that "validity refers to the degree to which evidence and theory support the interpretations of test scores entailed in the uses of tests" (p. 9). In other words, does the test measure what it is supposed to measure?

"The process of ascribing meaning to scores produced by a measurement procedure is generally recognized as the most important task in developing an educational or psychological measure, be it an achievement test, interest inventory, or personality scale" (Stenner, Smith, & Burdick, 1983). The appropriateness of any conclusions drawn from the results of a test are a function of the test's validity. The validity of a test is the degree to which the test actually measures what it purports to measure. Validity provides a direct check on how well the test fulfills its purpose.

The sections that follow describe the studies conducted to establish the validity of the *Reading Inventory*. As additional validity studies are conducted, they will be described in future editions of the *Reading Inventory Technical Guide*. For the sake of clarity, the various components of test validity—content validity, criterion-related validity, and construct validity—will be described as if they are unique, independent components rather than interrelated parts.

Content Validity

The content validity of a test refers to the adequacy with which relevant content has been sampled and represented in the test.

The Foundational Reading Assessment: Content Validity

The behavior domains that are assessed by the Foundational Reading Assessment are phonological awareness, letter name knowledge, letter sound knowledge, and decoding of sight words and nonwords. The phonological awareness items include rhyming and identification of first, last, and medial sounds. The letter items include both uppercase and lowercase letters. The sight word items were sampled from the first 100 of Fry's (2000) *1000 Instant Words*. The nonword items were constructed to sample commonly taught phonics skills, which also are the skills addressed in *iRead*. These include letter sounds, CVC patterns, blends, and VCe patterns. All items were reviewed by an expert panel for content validity and bias.

The Reading Comprehension Assessment: Content Validity

Content validity was built into the Reading Comprehension Assessment during its development. All authentic texts sampled for the Reading Comprehension Assessment items are developmentally appropriate. All passages written for use with items below 400L are developmentally appropriate and written for use on an assessment of reading comprehension. All items were written such that the student is asked to respond to the text in ways that are relevant to the text's genre (e.g., a student is asked specific questions related to an informational text's content rather than asked to make predictions about what would happen next in the text—a question more appropriate for narrative text).

For middle school and high school students who read below grade level, a subset of items from the main item pool is classified "Hi-Lo." The Hi-Lo pool of items was identified from all items developed for the Reading Comprehension Assessment based on whether they were developmentally appropriate for middle school and high school students (high interest) and had Lexile measures between 200L and 1000L (low difficulty). The administration of these items ensures that students will read developmentally appropriate content.

Criterion-Related Validity

The criterion-related validity of a test indicates the test's effectiveness in predicting an individual's behavior in a specific situation. Convergent validity examines those situations in which test scores are expected to be influenced by behavior; conversely, discriminate validity examines those situations in which test scores are not expected to be influenced by behavior.

Convergent validity looks at the relationships between test scores and other criterion variables (e.g., number of class discussions, reading comprehension grade equivalent, library usage, remediation). Because targeted reading intervention programs are specifically designed to improve students' reading ability, an effective intervention would be expected to improve students' reading test scores.

The Foundational Reading Assessment: Criterion-Related Validity

Criteria available to be predicted came from the DIBELS Next, which was administered to the *iRead* Screener Development Study sample along with the Foundational Reading Assessment. Predictive validity coefficients were calculated by using the Foundational Reading Assessment scores as predictors of DIBELS Next criterion scores. The resultant validity coefficients are presented in Tables 28, 29, and 30 for kindergarten, first grade, and second grade.

TABLE 28. Kindergarten predictive validity coefficients for Foundational Reading Assessment scores as predictors of DIBELS Next criterion scores, by grade.

Foundational Reading Assessment Score	DIBELS Next Criterion Scores		
	First Sound Fluency	Letter Naming Fluency	Composite
***Foundational Reading Assessment* Correct Scores**			
Total	.56**	.66**	.70**
Word-Level Reading	.52**	.66**	.67**
Word-Level Reading (w/o Letters)	.48**	.52**	.57**
Phonological Awareness	.60**	.51**	.62**
Letter Names and Sight Words	.51**	.63**	.66**
Letter Sounds and Nonwords	.44**	.53**	.55**
Letter Names	.40**	.59**	.57**
Sight Words	.48**	.52**	.58**
Letter Sounds	.45**	.63**	.61**
Nonwords	.32*	.36**	.39**
***Foundational Reading Assessment* Fluency Scores**			
Total	.44**	.57**	.58**
Word-Level Reading	.33**	.51**	.49**
Word-Level Reading (w/o Letters)	.25**	.37**	.35**
Phonological Awareness	.58**	.49**	.61**
Letter Names and Sight Words	.34**	.49**	.48**
Letter Sounds and Nonwords	.21**	.37**	.34**
Letter Names	.30**	.45**	.43**
Sight Words	.48**	.52**	.58**
Letter Sounds	.45**	.63**	.61**
Nonwords	.32*	.36**	.39**

* $p < .05$, ** $p < .01$

TABLE 29. First-grade predictive validity coefficients for Foundational Reading Assessment scores as predictors of DIBELS Next criterion scores, by grade.

Foundational Reading Assessment Score	DIBELS Next Criterion Scores			
	Letter Naming Fluency	Phoneme Segmentation Fluency	Nonsense Word Fluency	Composite
***Foundational Reading Assessment* Correct Scores**				
Total	.63**	.38**	.63**	.71**
Word-Level Reading	.62**	.35**	.62**	.70**
Word-Level Reading (w/o Letters)	.62**	.37**	.65**	.71**
Phonological Awareness	.56**	.39**	.47**	.60**
Letter Names and Sight Words	.61**	.30**	.52**	.60**
Letter Sounds and Nonwords	.57**	.36**	.63**	.69**
Letter Names	.27**	.17**	.14**	.23**
Sight Words	.62**	.31**	.54**	.61**
Letter Sounds	.30**	.14**	.20**	.29**
Nonwords	.57**	.36**	.64**	.69**
***Foundational Reading Assessment* Fluency Scores**				
Total	.70**	.36**	.68**	.73**
Word-Level Reading	.68**	.33**	.68**	.70**
Word-Level Reading (w/o Letters)	.67**	.31**	.72**	.70**
Phonological Awareness	.56**	.35**	.45**	.58**
Letter Names and Sight Words	.63**	.33**	.53**	.61**
Letter Sounds and Nonwords	.62**	.29**	.71**	.68**
Letter Names	.31**	.22**	.21**	.37**
Sight Words	.65**	.34**	.57**	.54**
Letter Sounds	.40**	.24**	.31**	.40**
Nonwords	.59*	.25**	.73**	.66**

* $p < .05$, ** $p < .01$

TABLE 30. Second-grade predictive validity coefficients for Foundational Reading Assessment scores as predictors of DIBELS Next criterion scores, by grade.

Foundational Reading Assessment Score	DIBELS Next Criterion Scores		
	Nonsense Word Fluency	Oral Reading Fluency	Composite
***Foundational Reading Assessment* Correct Scores**			
Total	.53**	.60**	.50**
Word-Level Reading	.60**	.70**	.57**
Word-Level Reading (w/o Letters)	.63**	.70**	.58**
Phonological Awareness	.33**	.44**	.42**
Letter Names and Sight Words	.40**	.49**	.39**
Letter Sounds and Nonwords	.62**	.68**	.59**
Letter Names	.00	.04	.09
Sight Words	.43**	.52**	.39**
Letter Sounds	.11	.09	.12*
Nonwords	.63*	.69**	.59**
***Foundational Reading Assessment* Fluency Scores**			
Total	.56**	.71**	.62**
Word-Level Reading	.59**	.72**	.64**
Word-Level Reading (w/o Letters)	.64**	.78**	.67**
Phonological Awareness	.33**	.47**	.45**
Letter Names and Sight Words	.36**	.49**	.43**
Letter Sounds and Nonwords	.63**	.75**	.67**
Letter Names	.07	.12*	.12*
Sight Words	.43**	.57**	.49**
Letter Sounds	.23**	.29**	.34**
Nonwords	.67*	.79**	.68**

* $p < .05$, ** $p < .01$

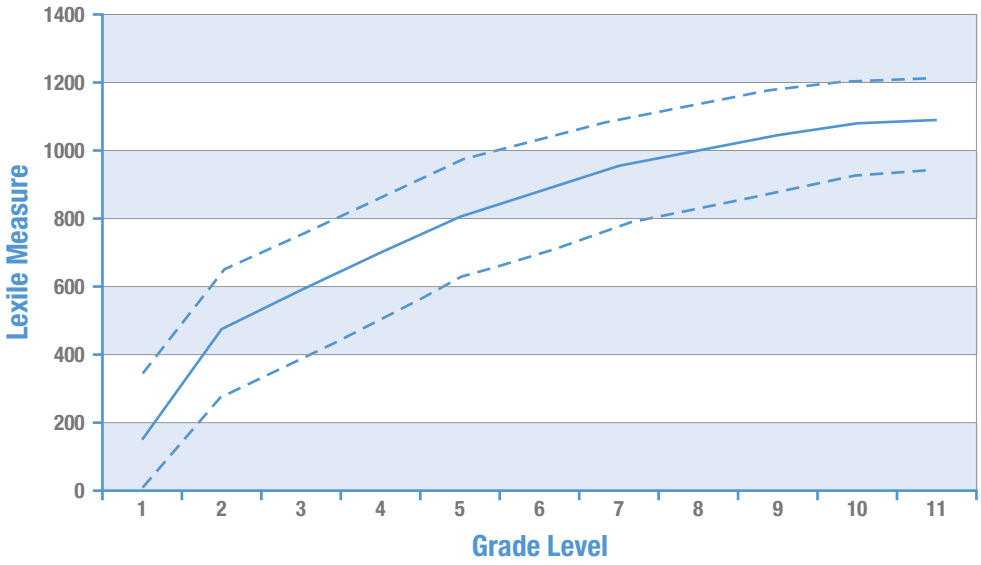
Substantial validity coefficients were found at the kindergarten, first-grade, and second-grade levels between DIBELS Next composite scores and Foundational Reading Assessment Total, Word-Level Reading, Word-Level Reading Without Letters, Letter Names and Sight Words, and Letter Sounds and Nonwords correct and fluency scores. Validity coefficients tended to be higher for fluency than for correct scores. At the kindergarten level, substantial validity coefficients were found for the Letter Name and Letter Sound tasks. In contrast, second-grade students' Letter Name and Letter Sound task performance was not related to DIBELS Next performance. Conversely, Nonword Reading was substantially related to DIBELS Next performance for first- and second-grade students, but not for kindergarten students who presumably could not decode many nonwords.

The Reading Comprehension Assessment: Criterion-Related Validity

READ 180 is a research-based reading intervention program designed to meet the needs of students in Grades 4–12 whose reading achievement is below the proficient level. *READ 180* was initially developed through collaboration between Vanderbilt University and the Orange County (FL) Public School System between 1991 and 1999. It combines research-based reading practices with the effective use of technology to offer students an opportunity to achieve reading success through a combination of instructional, modeled, and independent reading components. Because *READ 180* is a reading intervention program, students who participate in the program would be expected to show improvement in their reading comprehension as measured by the Reading Comprehension Assessment.

Reading comprehension generally increases as a student progresses through school. It increases rapidly during elementary school because students are specifically instructed in reading. In middle school, reading comprehension grows at a slower rate because instruction concentrates on specific content areas, such as science, literature, and social studies. The Reading Comprehension Assessment was designed to be a developmental measure of reading comprehension. Figure 14 shows the median performance (and upper and lower quartiles) of Lexile measures for students at each grade level. As predicted, student scores on the Reading Comprehension Assessment climb rapidly in elementary grades and level off in middle school.

FIGURE 14. Growth in Lexile measures—Median and upper and lower quartiles, by grade.

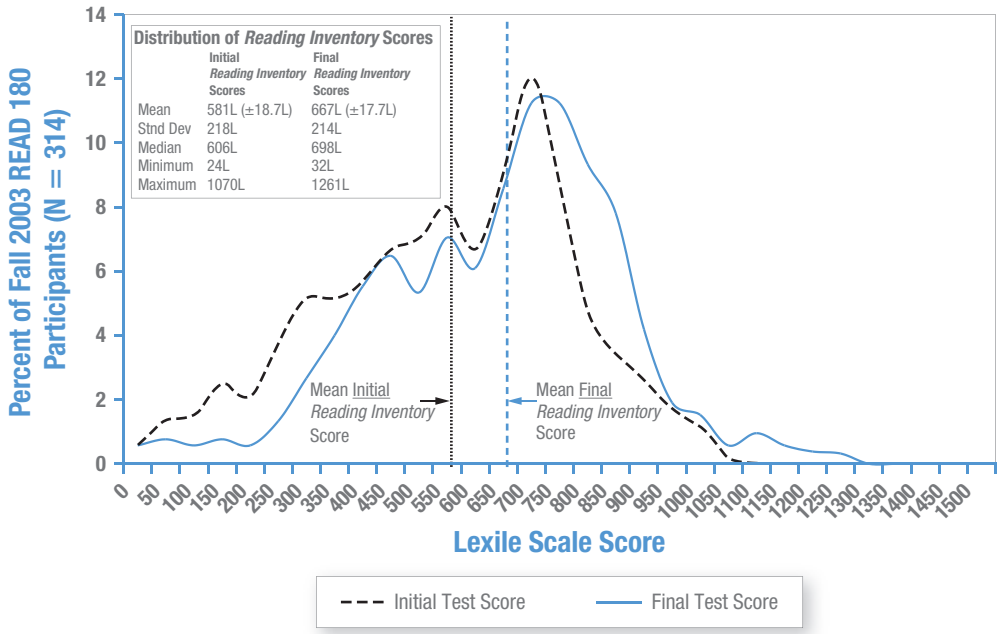


Discriminate validity looks at the relationships between test scores and other criterion variables that the scores should not be related to (e.g., gender, race/ethnicity). Reading Comprehension Assessment scores would not be expected to fluctuate according to the demographic characteristics of the students taking the test.

Study 1. During the 2003–2004 school year, the Memphis (TN) Public Schools remediated 525 students with *READ 180*® (Memphis Public Schools, no date). Pretests were administered between May 1, 2003, and December 1, 2003, and posttests were administered between January 1, 2004, and August 1, 2004. A minimum of one month and a maximum of 15 months elapsed between the pretest and posttest. Pretest scores ranged from 24L to 1070L with a mean of 581L (standard deviation of 606L). Posttest scores ranged from 32L to 1261L with a mean of 667L (standard deviation of 214L). The mean gain from pretest to posttest was 85.2L (standard deviation of 183L). Figure 15 shows the distribution of scores on the pretest and the posttest for all students.

FIGURE 15. Memphis (TN) Public Schools: Distribution of initial and final Reading Comprehension scores for *READ 180* participants.

Adapted from Memphis Public Schools (no date), Exhibit 2.



The results of the study show a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program.

Study 2. During the 2002–2003 school year, students at 14 middle schools in the Clark County (NV) School District participated in *READ 180* and completed the Reading Comprehension Assessment. Of the 4,223 students pretested in August through October and posttested in March through May, 399 students had valid numerical data for both the pretest and the posttest. Table 31 shows the mean gains in Lexile measures by grade level.

TABLE 31. Clark County (NV) School District: Lexile measures on the Reading Comprehension Assessment by grade level.

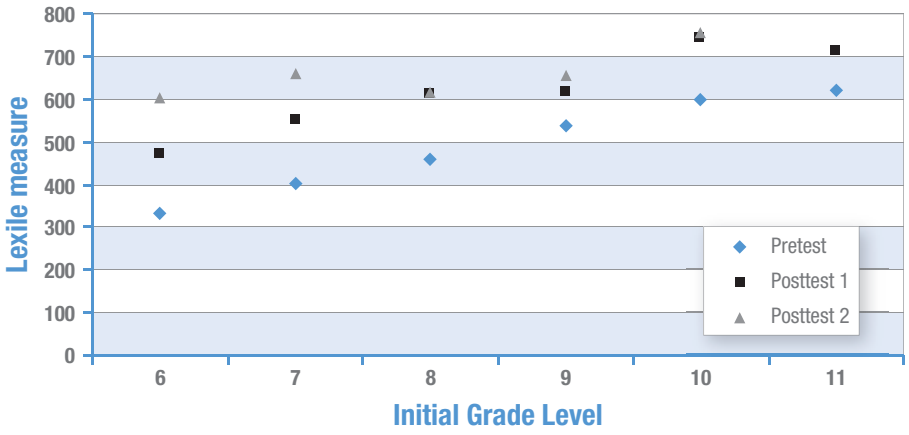
Grade	*N*	Pretest Mean (SD)	Posttest Mean (SD)	Gain (SD)
6	159	N/A	N/A	88.91 (157.24)**
7	128	N/A	N/A	137.84 (197.44)**
8	52	N/A	N/A	163.12 (184.20)**
Total	**339**	**461.09 (204.57)**	**579.86 (195.74)**	**118.77****

Adapted from Papalewis (2003), Table 4.
** $p < .01$, pre to post paired *t* test.

The results of the study show a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program.

Study 3. During the 2000–2001 through 2004–2005 school years, the Des Moines (IA) Independent Community School District administered *READ 180* to 1,213 Special Education middle school and high school students (Hewes, Mielke, & Johnson, 2006; Palmer, 2003). The Reading Comprehension Assessment was administered as a pretest to students entering the intervention program and as a posttest at the end of each school year. Reading Comprehension Assessment pretest scores were collected for 1,168 of the sampled students; posttest 1 scores were collected for 1,122 of the sampled students; and posttest 2 scores were collected for 361 of the sampled students. Figure 16 shows the mean pretest and posttest scores (1 and 2) for students in various cohorts. The standard deviation across all students was 257.40L.

FIGURE 16. Des Moines (IA) Independent Community School District: Group Reading Comprehension Assessment mean Lexile measures, by starting grade level in *READ 180.*



As shown in Figure 16, reading ability as measured by the Reading Comprehension Assessment increased from the initial grade level of the student. In addition, when the students' cohort, starting grade, pattern of participation, and level of Special Education were controlled for, students grew at a rate of 39.68L for each year of participation in *READ 180* (effect size =.15; NCE = 3.16). "These were annual gains associated with *READ 180 above and beyond* yearly growth in achievement" (Hewes, Mielke, & Johnson, 2006, p. 14). Students who started *READ 180* in middle school (Grades 6 and 7) improved the most.

Study 4. The St. Paul (MN) School District implemented *READ 180* in middle schools during the 2003–2004 school year (St. Paul School District, no date). A total of 820 students were enrolled in *READ 180* (45% regular education, 34% English language learners, 15% Special Education, and 6% ELL/SPED); and, of those students, 44% were African American, 30% Asian, 15% Caucasian, 9% Hispanic, and 2% Native American. Of the 820 students in the program, 573 students in Grades 7 and 8 had complete data for the Reading Comprehension Assessment. The mean group pretest score was 659.0L, and the mean group posttest score was 768.5L with a gain of 109.5L ($p < .01$). The results of the study show a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program.

Study 5. Fairfax County (VA) Public Schools implemented *READ 180* for 548 students in Grades 7 and 8 at 11 middle schools during the 2002–2003 school year (Pearson & White, 2004). The general population at the 11 schools was as follows: 45% Caucasian, 22% Hispanic, and 18% African American; 55% male and 45% female; 16% classified as English for Speakers of Other Languages (ESOL); and 25% classified as receiving Special Education services. The sample of students enrolled in *READ 180* can be described as follows: 15% Caucasian, 37% Hispanic, and 29% African American; 52% male and 48% female; 42% classified as ESOL; and 14% classified as receiving Special Education services. The population that participated in the *READ 180* program can be considered significantly different from the general population in terms of race/ethnicity, ESOL classification, and Special Education services received.

Pretest Lexile measures from the Reading Comprehension Assessment ranged from 136L to 1262L with a mean of 718L (standard deviation of 208L). Posttest Lexile measures from the Reading Comprehension Assessment ranged from 256L to 1336L with a mean of 815L (standard deviation of 203L). The mean gain from pretest to posttest was 95.9L (standard deviation of 111.3L). The gains in Lexile measures were statistically significant, and the effect size was 0.46 standard deviations. The results of the study showed a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program.

The study also examined the gains of various subgroups of students and observed that "no statistically significant differences in the magnitude of pretest-posttest changes in reading ability were found to be associated with other characteristics of *READ 180* participants . . . gender, race, eligibility for ESOL, eligibility for Special Education, and the number of days the student was absent from school during 2002–03" (Pearson & White, 2004, p. 13).

Study 6. Indian River (DE) School District piloted *READ 180* at Shelbyville Middle School during the 2003–2004 school year for students in Grades 6–8 performing in the bottom quartile of standardized assessments (Indian River School District, no date). During the 2004–2005 school year, the Reading Comprehension Assessment was administered to all students in the district enrolled in *READ 180* (the majority of students also received Special Education services). Table 32 presents the descriptive statistics for students enrolled in *READ 180* at Shelbyville Middle School and Sussex Central Middle School.

TABLE 32. Indian River (DE) School District: Reading Comprehension Assessment average scores (Lexile measures) for *READ 180* students in 2004–05.

Grade	*N*	Fall Lexile Measure (Mean/SD)	Spring Lexile Measure (Mean/SD)
6	65	498.0 (242.1)	651.2 (231.7)
7	57	518.0 (247.7)	734.8 (182.0)
8	62	651.5 (227.8)	818.6 (242.9)

Adapted from Indian River School District (no date), Table 1.

Based on the results, the increase in students classified as "Reading at Grade Level" was 18.5% in Grade 6, 13.4% in Grade 7, and 26.2% in Grade 8. "Students not only showed improvement in the quantitative data, they also showed an increase in their positive attitudes toward reading in general" (Indian River School District, no date, p. 1). The results of the study show a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program. In addition, Reading Comprehension Assessment scores monotonically increased across grade levels.

Study 7. In response to a drop-out problem with Special Education students at Fulton Middle School (Callaway County, GA), *READ 180* was implemented in 2005 (Sommerhauser, 2006). Students in Grades 6 and 7 whose reading skills were significantly below grade level ($N = 24$) participated in the program. The results showed that "20 of the 24 students have shown improvement in their Lexile scores, a basic reading test."

Study 8. East Elementary School in Kodiak, Alaska, instituted a reading program in 2000 that matched readers with text at their level of comprehension (MetaMetrics, 2006c). Students were administered the Reading Comprehension Assessment as part of the *Reading Counts!* program and encouraged to read books at their Lexile level. Reed, the school reading specialist, stated that the program has led to more books being checked out of the library, increased student enthusiasm for reading, and increased teacher participation in the program (e.g., lesson planning, materials selection across all content areas).

Study 9. The Kirkwood (MO) School District Implemented *READ 180* between 1999 and 2003 (Thomas, 2003). Initially, students in Grades 6–8 were enrolled. In subsequent years, the program was expanded to include students in Grades 4–8. The program served: 379 students during the 2000–2001 school year (34% classified as Special Education/SSD); 311 students during the 2001–2002 school year (43% classified as Special Education/SSD); and 369 students during the 2002–2003 school year (41% classified as Special Education/SSD). Figures 17 through 19 show the pretest and posttest scores of general education students for three years of the program.

FIGURE 17. Kirkwood (MO) School District: Pretest and posttest Reading Comprehension Assessment scores, school year 2000–2001, general education students.

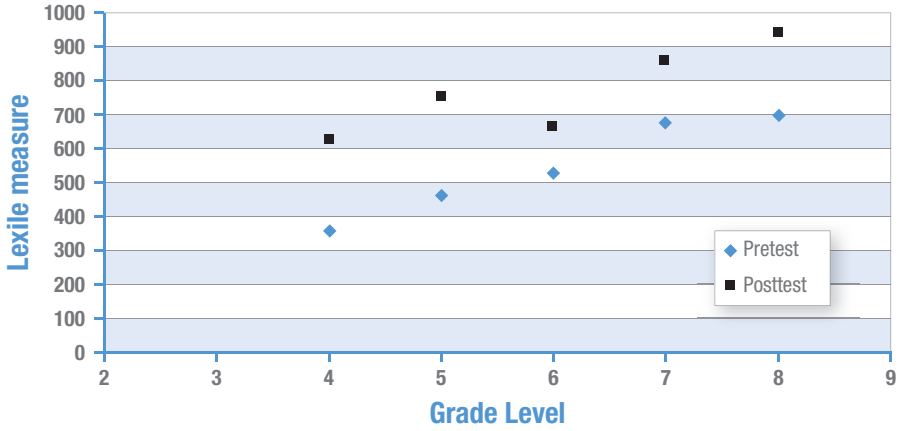


FIGURE 18. Kirkwood (MO) School District: Pretest and posttest Reading Comprehension Assessment scores, school year 2001–2002, general education students.

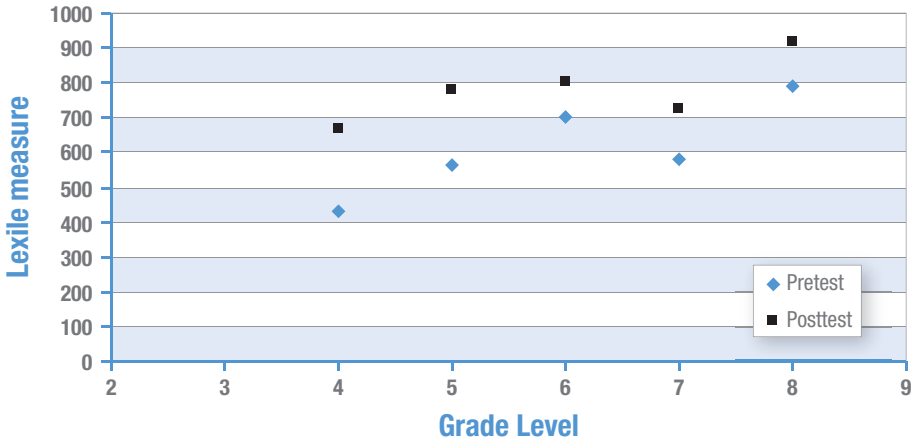
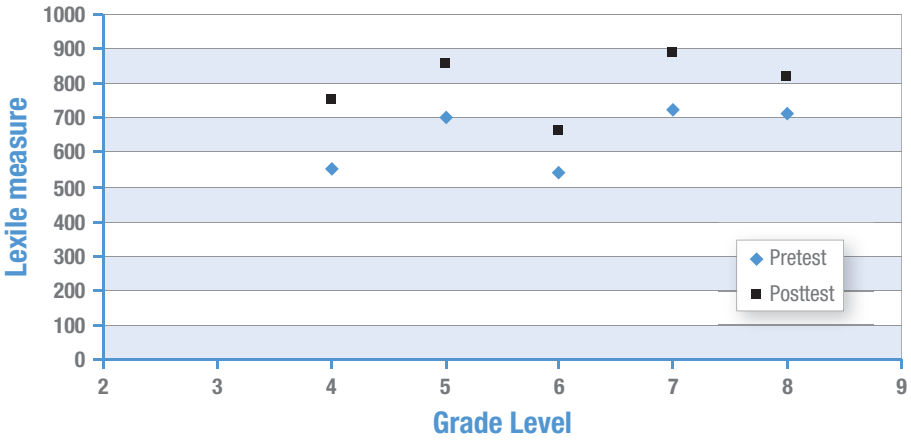


FIGURE 19. Kirkwood (MO) School District: Pretest and posttest Reading Comprehension Assessment scores, school year 2002–2003, general education students.



The results of the study show a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program (within-school-year gains for 90% of students enrolled in the program). The study concluded that "fourth- and fifth-grade students have higher increases than middle school students, reinforcing the need for earliest intervention. Middle school scores, however, are influenced by higher numbers of new students needing reading intervention" (Thomas, 2003, p. 7).

Study 10. In Fall 2003, the Phoenix (AZ) Union High School District began using Stage C of *READ 180* to help struggling ninth- and tenth-grade students become proficient readers and increase their opportunities for success in school (White and Haslam, 2005). Of the Grade 9 students ($N = 882$) who participated, 49% were classified as ELL and 9% were eligible for Special Education services. Information was not provided for the Grade 10 students ($N = 697$).

For students in Grade 9, the mean gain from the Reading Comprehension Assessment pretest to posttest was 111L. For students in Grade 10, the mean gain from pretest to posttest was 69L for the fall cohort and 111L for the spring cohort. The gains in Lexile measures were statistically significant at the .05 level. The results of the study showed a positive relationship between Reading Comprehension Assessment scores and enrollment in a reading intervention program.

The study also examined the gains of various subgroups of students. No significant differences were observed between students classified as ELL and non-ELL students (ELL gain scores of 13.3 NCEs and non-ELL gain scores of 13.5 NCEs, $p < .86$). No significant differences were observed between students eligible for Special Education services and those not eligible (Special Education gain scores of 13.7 NCEs and non-Special Education gain scores of 13.5 NCEs, $p < .88$).

Study 11. A large urban school district administered the Reading Comprehension Assessment to all students in Grades 2 through 10. Data were collected from the 2000–2001 school year through the 2006–2007 school year and were matched at the student level. All students were administered the Reading Comprehension Assessment at the beginning of the school year (September) and in March, and a sample of students in intervention programs was administered the Reading Comprehension Assessment in December also. Information was collected on race/ethnicity, gender, and limited English proficiency (LEP) classification. The student demographic data presented in Table 33 is from the 2004–2005 school year.

TABLE 33. Large urban school district: Reading Comprehension Assessment scores by student demographic classification.

Student Demographic Characteristic	*N*	Mean (SD)
Race/Ethnicity		
• Asian	3,498	979.90 (316.21)
• Black	35,500	753.43 (316.55)
• Hispanic	27,260	790.24 (338.11)
• Native American	723	868.41 (311.20)
• Multiracial	5,305	906.42 (310.10)
• White	65,124	982.54 (303.79)
Gender		
• Female	68,454	898.21 (316.72)
• Male	68,956	865.10 (345.26)
Limited English Proficiency Status		
• Former LEP student	6,926	689.73 (258.22)
• Limited English and in ESOL program	7,459	435.98 (292.68)
• Exited from ESOL program	13,917	890.52 (288.37)
• Never in ESOL program	109,108	923.10 (316.67)

Given the sample sizes, the contrasts are significant. Using the rule of thumb that a quarter of a standard deviation represents an educational difference, the data shows that whites score significantly higher than all other groups except Asians. The data do not show any differences based on gender, and the observed differences based on LEP status are expected.

Construct Validity

The construct validity of a test is the extent to which the test may be said to measure a theoretical construct or trait, such as reading ability.

The Foundational Reading Assessment: Construct Validity

Construct-identification validity is a global form of validity that encompasses evidence provided about the content-description validity and criterion-prediction validity of a test, but includes other evidence as well. For the Foundational Reading Assessment, one test of construct-identification validity is whether the factor structure of the measure conforms to predictions based on theories of early reading.

Confirmatory factor analyses were carried out on both correct scores and fluency scores separately by grade. Model fit statistics are presented in Table 34, and the results are presented in Figures 20 through 25.

TABLE 34. Model fit statistics for Foundational Reading Assessment scores, by grade.

MODEL	FIT STATISTICS						
	X^2	df	*p*	TLI	CFI	RMSEA (90CI)	*p*-close
Kindergarten (correct scores)	39.4	17	.002	.952	.971	.05 (.32–.76)	.359
First Grade (correct scores)	47.8	17	< .001	.957	.980	.06 (.04–.08)	.182
Second Grade (correct scores)	32.3	8	< .001	.896	.960	.095 (.06–.12)	.027
Kindergarten (fluency scores)	41.6	18	.001	.962	.981	.05 (.03–.07)	.424
First Grade (fluency scores)	41.3	17	.001	.959	.981	.05 (.03–.08)	.359
Second Grade (fluency scores)	29.8	8	< .001	.904	.964	.08 (.05–.11)	.046

Notes. X^2 = Chi Square. df = degrees of freedom. *p* = probability value. TLI = Tucker-Lewis Index. CFI = Comparative Fit Index. RMSEA = Root Mean Squared Error of Approximation. *p*-close = probability of a close fitting model.

The model fit statistics support the fit of the models in that all models met criteria for either an adequate or a good fit.

FIGURE 20. Kindergarten confirmatory factor analysis for correct scores.

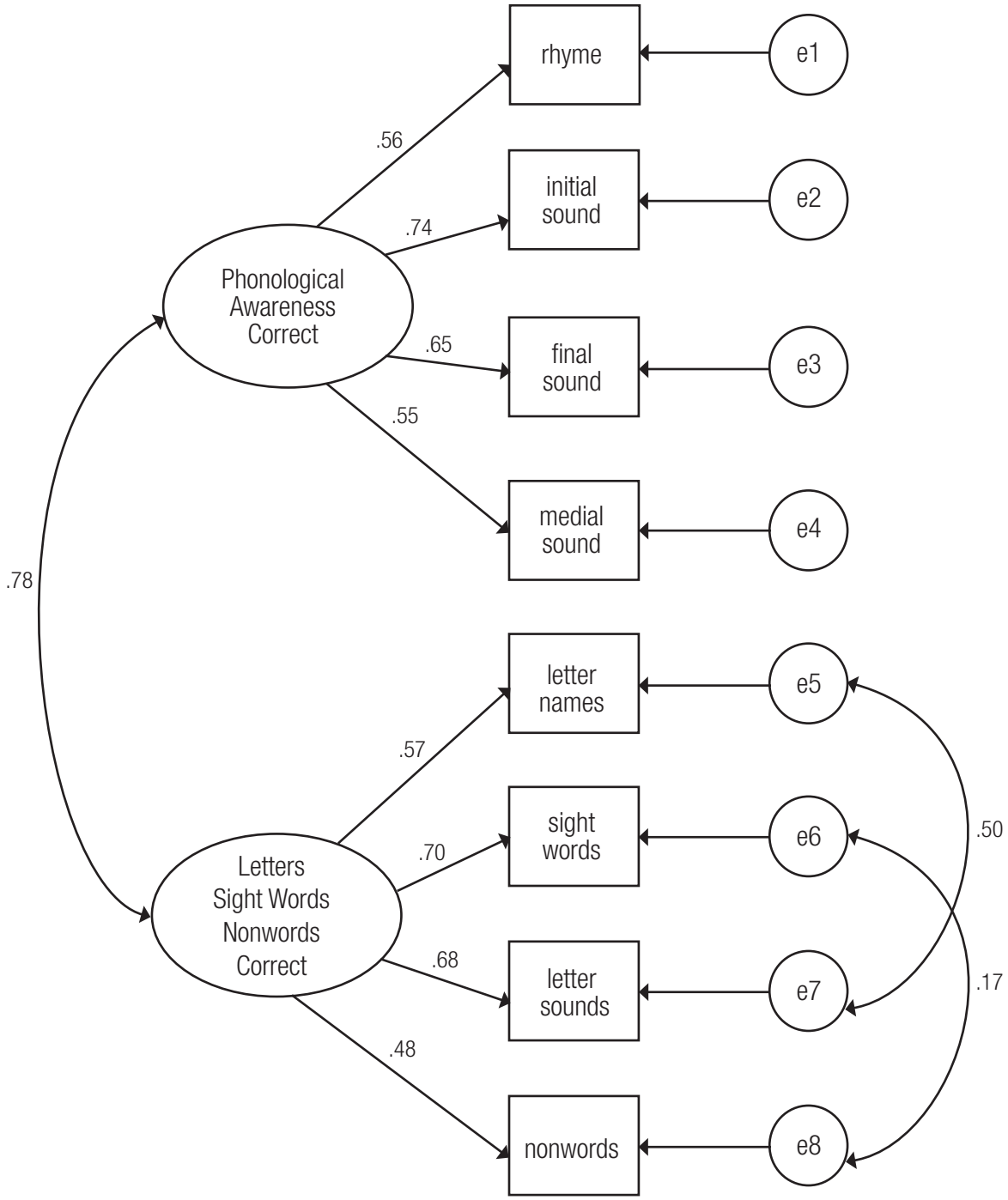


FIGURE 21. First-grade confirmatory factor analysis for correct scores.

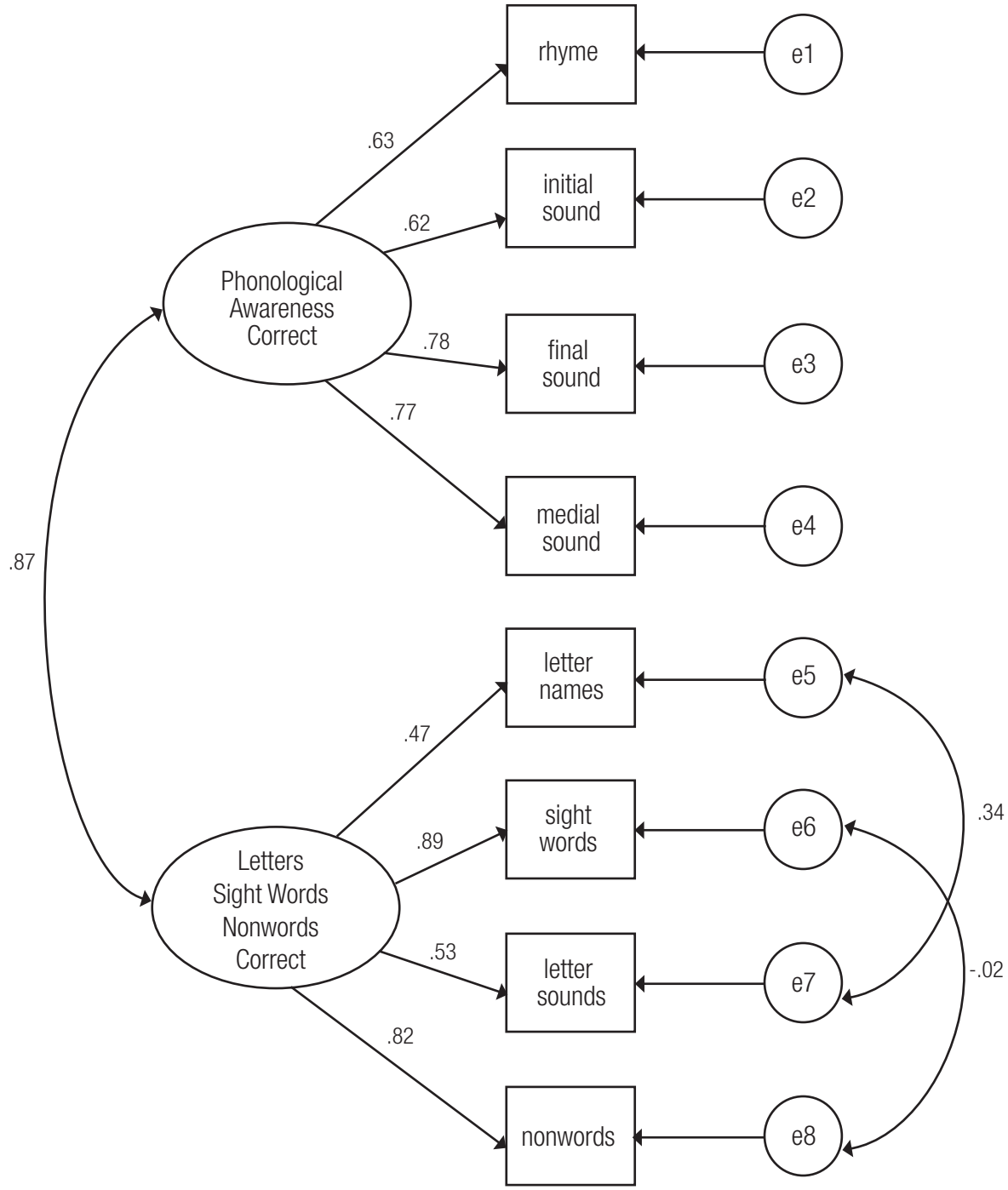


FIGURE 22. Second-grade confirmatory factor analysis for correct scores.

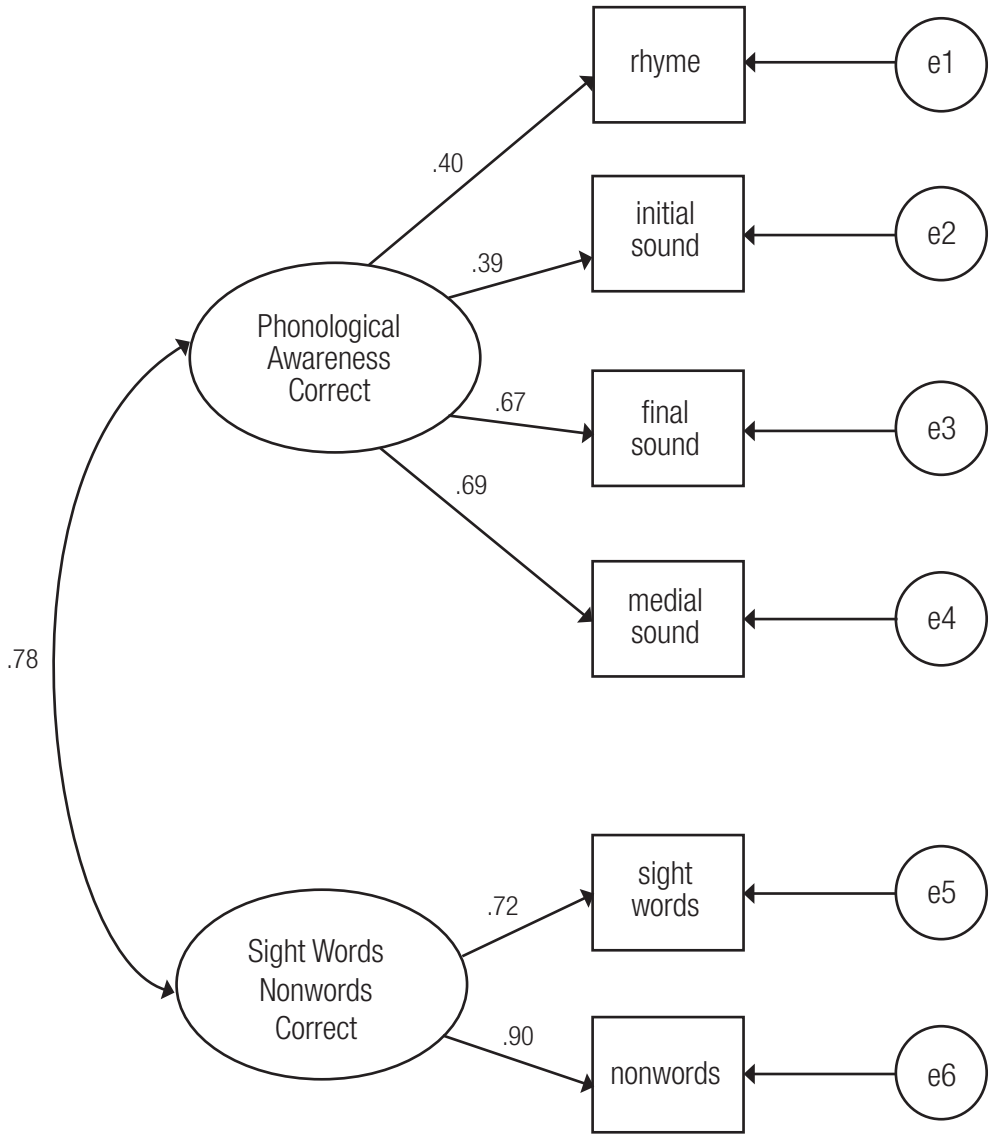


FIGURE 23. Kindergarten confirmatory factor analysis for fluency.

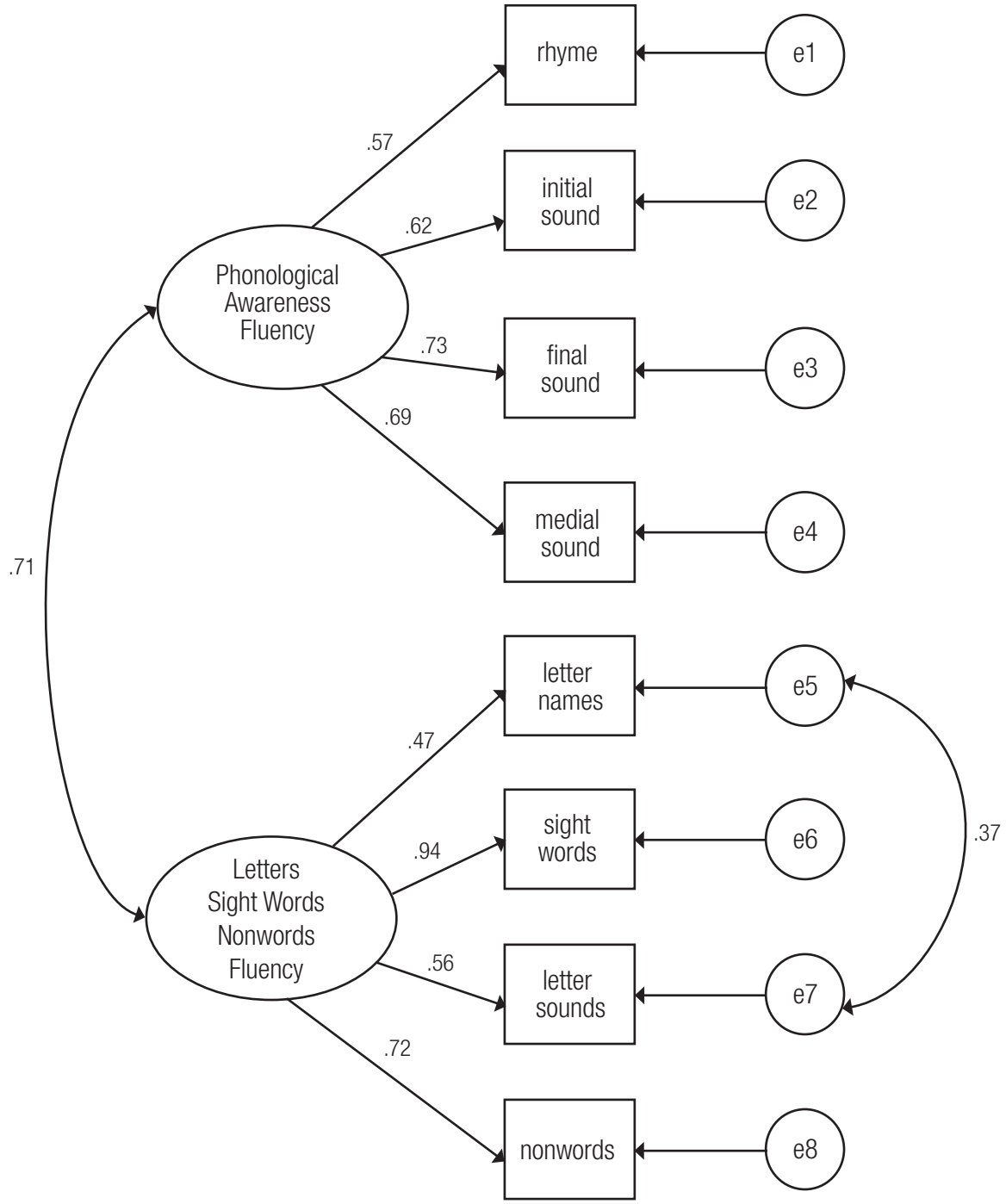


FIGURE 24. First-grade confirmatory factor analysis for fluency.

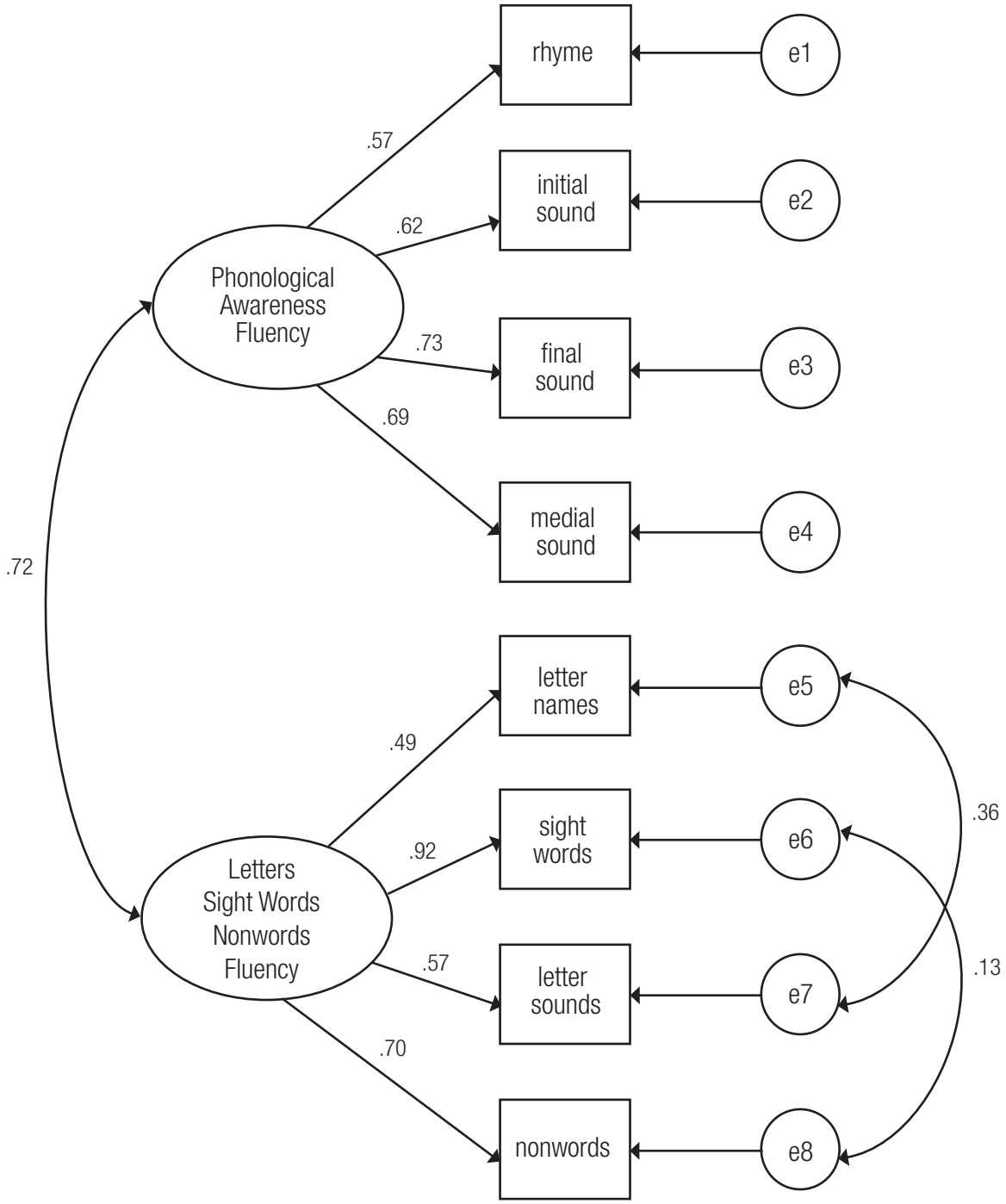
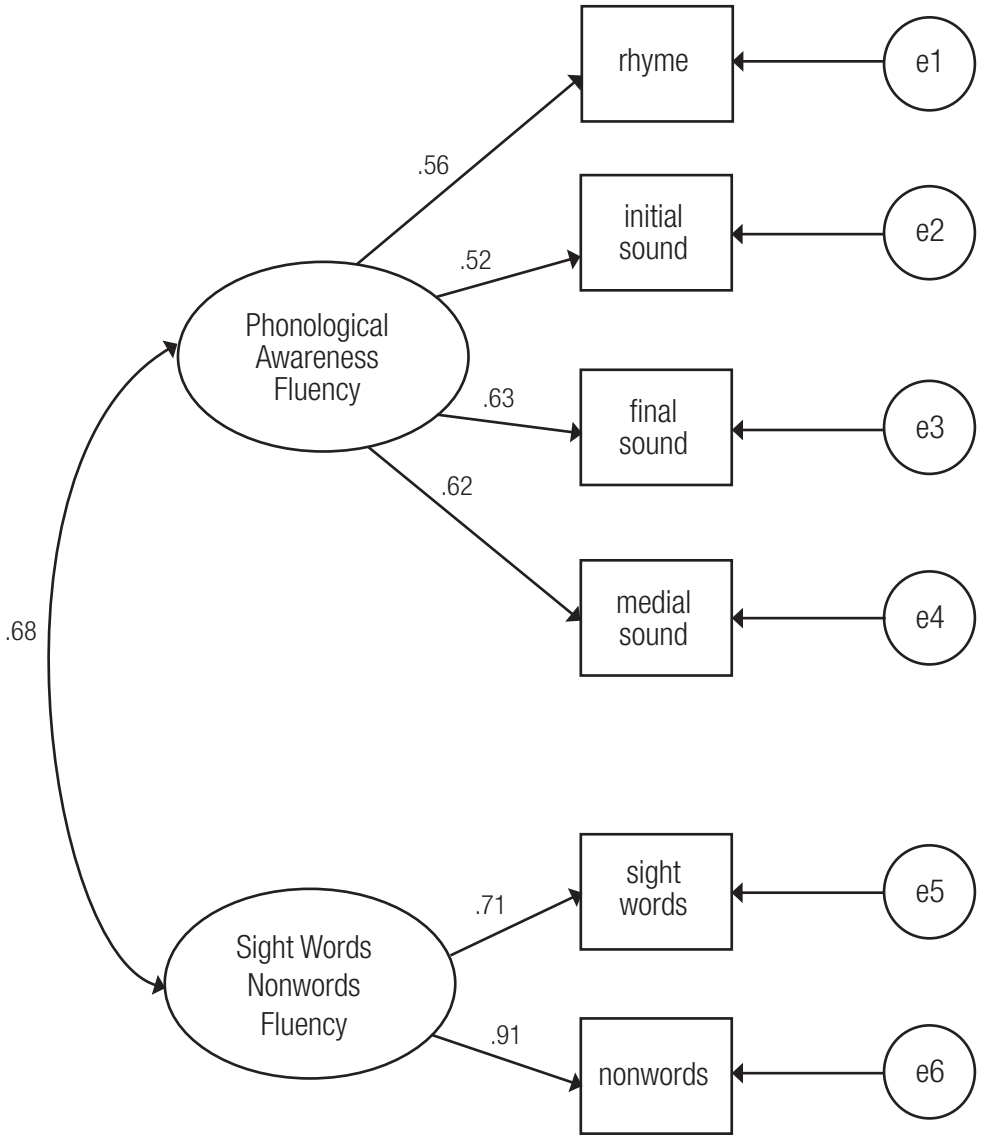


FIGURE 25. Second-grade confirmatory factor analysis for fluency.



The Reading Comprehension Assessment: Construct Validity

Anastasi (1982) identifies a number of ways that the construct validity of a test can be examined. Two of the techniques are appropriate for examining the construct validity of the Reading Comprehension Assessment. One technique is to examine developmental changes in test scores for traits that are expected to increase with age. Another technique is to examine the "correlations between a new test and other similar tests . . . [the correlations are] evidence that the new test measures approximately the same general areas of behavior as other tests designated by the same name" (p. 145).

Construct validity is the most important aspect of validity related to the Reading Comprehension Assessment. The Reading Comprehension Assessment is designed to measure the development of reading comprehension; therefore, how well it measures reading comprehension and how well it measures the development of reading comprehension must be examined.

Reading Comprehension Construct. Reading comprehension is the process of independently constructing meaning from text. Scores from tests purporting to measure the same construct, for example "reading comprehension," should be moderately correlated (Anastasi, 1982). (For more information related to how to interpret multiple test scores reported in the same metric, see the paper entitled "Managing Multiple Measures" by Gary L. Williamson (2006) located at www.lexile.com.)

Study 1. During the 2000–2001 through 2004–2005 school years, the Des Moines (IA) Independent Community School District enrolled 1,213 Special Education middle and high school students in *READ 180*. The Reading Comprehension Assessment was administered as a pretest to students entering *READ 180* and annually at the end of each school year as a posttest. A correlation of 0.65 ($p < .05$) was observed between the Reading Comprehension Assessment and the Stanford Diagnostic Reading Test (SDRT-4) Comprehension subtest; a correlation of 0.64 ($p < .05$) was observed between the Reading Comprehension Assessment and the SDRT-4 Vocabulary subtest; and a correlation of 0.65 ($p < .05$) was observed between the Reading Comprehension Assessment and the SDRT-4 Total score. "The low correlations observed for this sample of students may be related to the fact that this sample is composed exclusively of Special Education students" (Hewes, Mielke, & Johnson, 2006, p. A-3).

Study 2. The Kirkwood (MO) School District Implemented *READ 180* between 1999 and 2003 (Thomas, 2003). Initially, students in Grades 6–8 were enrolled in the program. In subsequent years, the program was expanded to students in Grades 4–8. In addition to the Reading Comprehension Assessment, the Standardized Test for the Assessment of Reading (STAR) was administered. "There is nearly an exact correlation between the two measures in terms of ranking students and distinguishing between regular and Special Education students' performance" (Thomas, 2003, p. 6).

Study 3. A large urban school district administered the Reading Comprehension Assessment to all students in Grades 2–10. Data were collected from the 2000–2001 school year through the 2006–2007 school year and were matched at the student level. All students were administered the Reading Comprehension Assessment at the beginning of the school year (September) and in March, and a sample of students in intervention programs was administered the Reading Comprehension Assessment in December also. Students were also administered the state assessment, the Florida Comprehensive Assessment Test, which consists of a norm-referenced assessment (Stanford Achievement Tests, Ninth or Tenth Edition [SAT-9/10]) and a criterion-referenced assessment (Sunshine State Standards Test [SSS]). In addition, a sample of students were administered the PSAT. Tables 35 through 37 show the descriptive statistics for matched samples of students during several years of data collection.

TABLE 35. Large urban school district: Descriptive statistics for the Reading Comprehension Assessment and the SAT-9/10, matched sample.

School Year	Reading Comprehension Assessment		SAT-9/10 (reported in Lexile measures)		*r*
	N	Mean (SD)	N	Mean (SD)	
2001–2002	79,423	848.22 (367.65)	87,380	899.47 (244.30)	0.824
2002–2003	80,677	862.42 (347.03)	88,962	909.54 (231.29)	0.800
2003–2004	84,707	895.70 (344.45)	91,018	920.94 (226.30)	0.789
2004–2005	85,486	885.07 (349.40)	101,776	881.11 (248.53)	0.821

TABLE 36. Large urban school district: Descriptive statistics for the Reading Comprehension Assessment and the SSS, matched sample.

School Year	*Reading Inventory*		SSS		*r*
	N	Mean (SD)	N	Mean (SD)	
2001–2002	79,423	848.22 (367.65)	87,969	1641 (394.98)	0.835
2002–2003	80,677	862.42 (347.03)	90,770	1679 (368.26)	0.823
2003–2004	84,707	895.70 (344.45)	92,653	1699 (361.46)	0.817
2004–2005	85,486	885.07 (349.40)	104,803	1683 (380.13)	0.825

TABLE 37. Large urban school district: Descriptive statistics for the Reading Comprehension Assessment and the PSAT, matched sample.

School Year	*Reading Inventory*		PSAT		*r*
	N	Mean (SD)	N	Mean (SD)	
2002–2003	80,677	862.42 (347.03)	2,219	44.48 (11.70)	0.730
2003–2004	84,707	895.70 (344.45)	2,146	41.86 (12.14)	0.696
2004–2005	85,486	885.07 (349.40)	1,731	44.64 (11.40)	0.753

From the results it can be concluded that the Reading Comprehension Assessment measures a construct similar to that measured by other standardized tests designed to measure reading comprehension. The magnitude of the within-grade correlations between the Reading Comprehension Assessment and the PSAT is close to the observed correlations for parallel test forms (i.e., alternate forms reliability), thus suggesting that the different tests are measuring the same construct. The SAT-9/10, SSS, and PSAT consist of passages followed by traditional multiple-choice items, and the Reading Comprehension Assessment consists of embedded completion multiple-choice items. Despite the differences in format, the correlations suggest that the four assessments are measuring a similar construct.

Study 4. In 2005, a group of 20 Grade 4 students at a Department of Defense Education Activity (DoDEA) school in Fort Benning (GA) were administered both the Reading Comprehension Assessment and the Reading Comprehension Assessment-Print (Level 14, Form B). The correlation between the two Lexile measures was 0.92 (MetaMetrics, 2005). The results show that the two tests measure similar reading constructs.

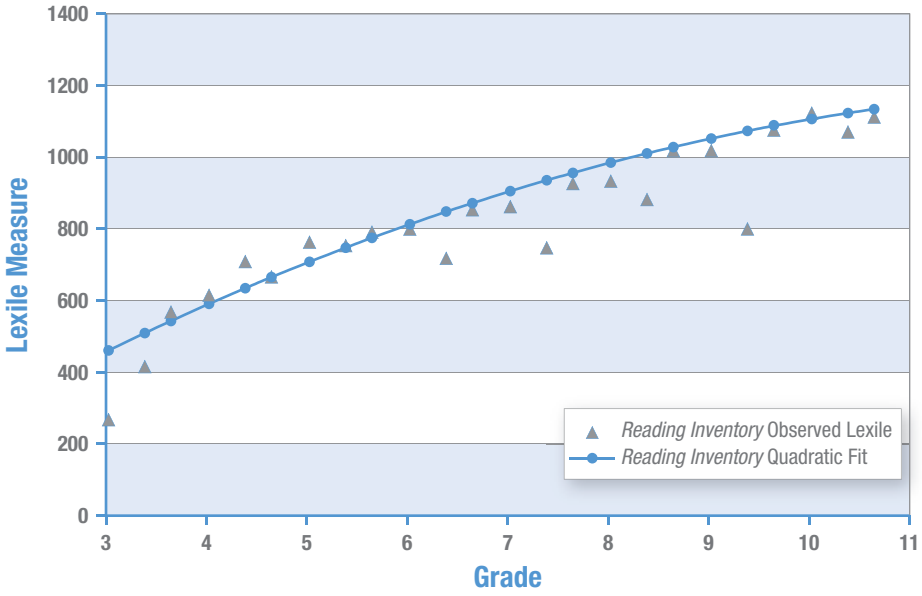
Developmental Nature of the Reading Comprehension Assessment. Reading is a skill that is expected to develop with age—as students read more, their skills improve, and therefore they are able to read more complex material. Because growth in reading comprehension is uneven, with the greatest growth usually taking place in earlier grades, the Reading Comprehension Assessment scores should show a similar trend of decreasing gains as grade level increases.

Study 1. A middle school in the Pasco County (FL) School District administered the Reading Comprehension Assessment during the 2005–2006 school year to 721 students. Growth in reading ability was examined by collecting data in September and April. The mean Lexile measure in September across all grades was 978.26L (standard deviation of 194.92L), and the mean Lexile measure in April was 1026.12L (standard deviation of 203.20L). The mean growth was 47.87L (standard deviation of 143.09L). The typical growth for middle school students is approximately 75L across a calendar year (Williamson, Thompson, & Baker, 2006). When the growth for the sample of students in Pasco County was prorated to compare with a typical year's growth, 73.65L was consistent with prior research. In addition, when the data were examined by grade level, it was observed that Grade 6 exhibited the most growth, while growth tapered off in later grades (Grade 6, $N = 211$, Growth $= 56$L [prorated 87L]; Grade 7, $N = 254$, Growth $= 52$L [prorated 79L]; Grade 8, $N = 256$, Growth $= 37$L [prorated 58L]).

Study 2. A large urban school district administered the Reading Comprehension Assessment to all students in Grades 2–10. Data were collected from the 2000–2001 school year through the 2006–2007 school year and were matched at the student level. All students were administered the Reading Comprehension Assessment at the beginning of the school year (September) and in March, and a sample of students in intervention programs was administered the Reading Comprehension Assessment in December also.

The data were examined to estimate growth in reading ability using a quadratic regression equation. Students with at least seven Reading Comprehension Assessment scores were included in the analyses (45,495 students out of a possible 172,412). The resulting quadratic regression slope was slightly more than 0.50L/day (about 100L of growth between fall and spring), which is consistent with prior research conducted by MetaMetrics, Inc. (Williamson, Thompson, & Baker, 2006). The median R-squared coefficient was between .800 and .849, which indicates that the correlation between reading ability and time is approximately 0.91. Figure 26 shows the fit of the model compared to observed Reading Comprehension Assessment data.

FIGURE 26. Large Urban School District: Fit of quadratic growth model to Reading Comprehension Assessment data for students in Grades 2–10.



Appendices

Appendix A: Lexile Framework Map

Connecting curriculum-based reading to the Lexile Framework, the titles in this chart are typical of texts that developmentally correspond to Lexile level.

There are many readily available texts that have older interest levels but a lower Lexile level (hi-lo titles). Conversely, there are many books that have younger interests but are written on a higher Lexile level (adult-directed picture books). By evaluating the Lexile level for any text, educators can provide reading opportunities that foster student growth.

For more information on the Lexile ranges for additional titles, please visit www.lexile.com or the *Reading Counts!* e-Catalog at hmhco.com.

LEXILE LEVEL	BENCHMARK LITERATURE	BENCHMARK NONFICTION TEXTS
200L	**Clifford The Big Red Dog** *by Norman Bridwell* **(220L)** **Amanda Pig, Schoolgirl** *by Jean Van Leeuwen* **(240L)** **The Cat in the Hat** *by Dr. Seuss* **(260L)**	**Inch by Inch** *by Leo Lionni* **(210L)** **Harbor** *by Donald Crews* **(220L)** **Ms. Frizzle's Adventure: Medieval Castles** *by Joanna Cole* **(270L)**
300L	**Hey, Al!** *by Arthur Yorinks* **(320L)** **"A" My Name is Alice** *by Jane Bayer* **(370L)** **Arthur Goes to Camp** *by Marc Brown* **(380L)**	**You Forgot Your Skirt, Amelia Bloomer** *by Shana Corey* **(350L)** **George Washington and the General's Dog** *by Frank Murphy* **(380L)** **How A Book is Made** *by Aliki* **(390L)**
400L	**Frog and Toad are Friends** *by Arnold Lobel* **(400L)** **Cam Jansen and the Mystery of the Stolen Diamonds** *by David A. Adler* **(420L)** **Bread and Jam for Frances** *by Russell Hoban* **(490L)**	**How My Parents Learned to Eat** *by Ina R. Friedman* **(450L)** **Finding Providence** *by Avi* **(450L)** **When I Was Nine** *by James Stevenson* **(470L)**
500L	**Bicycle Man** *by Allen Say* **(500L)** **Can I Keep Him?** *by Steven Kellogg* **(510L)** **The Music of Dolphins** *by Karen Hesse* **(560L)**	**By My Brother's Side** *by Tiki Barber* **(500L)** **The Wild Boy** *by Mordicai Gerstein* **(530L)** **The Emperor's Egg** *by Martin Jenkins* **(570L)**
600L	**Artemis Fowl** *by Eoin Colfer* **(600L)** **Sadako and the Thousand Paper Cranes** *by Eleanor Coerr* **(630L)** **Charlotte's Web** *by E. B. White* **(680L)**	**Koko's Kitten** *by Dr. Francine Patterson* **(610L)** **Lost City: The Discovery of Machu Picchu** *by Ted Lewin* **(670L)** **Passage to Freedom: The Sugihara Story** *by Ken Mochizuki* **(670L)**

LEXILE LEVEL	BENCHMARK LITERATURE	BENCHMARK NONFICTION TEXTS
700L	**Bunnicula** *by Deborah Howe, James Howe* **(710L)** **Beethoven Lives Upstairs** *by Barbara Nichol* **(750L)** **Harriet the Spy** *by Louise Fitzhugh* **(760L)**	**Journey to Ellis Island: How My Father Came to America** *by Carol Bierman* **(750L)** **The Red Scarf Girl** *by Ji-li Jiang* **(780L)** **Four Against the Odds** *by Stephen Krensky* **(790L)**
800L	**Interstellar Pig** *by William Sleator* **(810L)** **Charlie and the Chocolate Factory** *by Roald Dahl* **(810L)** **Julie of the Wolves** *by Jean Craighead George* **(860L)**	**Can't You Make Them Behave, King George?** *by Jean Fritz* **(800L)** **Anthony Burns: The Defeat and Triumph of a Fugitive Slave** *by Virginia Hamilton* **(860L)** **Having Our Say: The Delany Sisters' First 100 Years** *by Sarah L. Delany and A. Elizabeth Delany* **(890L)**
900L	**Roll of Thunder, Hear My Cry** *by Mildred D. Taylor* **(920L)** **Abel's Island** *by William Steig* **(920L)** **The Slave Dancer** *by Paula Fox* **(970L)**	**October Sky** *by Homer H. Hickam, Jr.* **(900L)** **Black Boy** *by Richard Wright* **(950L)** **All Creatures Great and Small** *by James Herriott* **(990L)**
1000L	**Hatchet** *by Gary Paulsen* **(1020L)** **The Great Gatsby** *by F. Scott Fitzgerald* **(1070L)** **Their Eyes Were Watching God** *by Zora Neale Hurston* **(1080L)**	**The Greatest: Muhammad Ali** *by Walter Dean Myers* **(1030L)** **Anne Frank: Diary of A Young Girl** *by Anne Frank* **(1080L)** **My Thirteenth Winter** *by Samantha Abeel* **(1050L)**
1100L	**Pride and Prejudice** *by Jane Austen* **(1100L)** **Ethan Frome** *by Edith Wharton* **(1160L)** **Animal Farm** *by George Orwell* **(1170L)**	**Black Diamond** *by Patricia McKissack* **(1100L)** **Dead Man Walking** *by Helen Prejean* **(1140L)** **Hiroshima** *by John Hersey* **(1190L)**
1200L	**Great Expectations** *by Charles Dickens* **(1200L)** **The Midwife's Apprentice** *by Karen Cushman* **(1240L)** **The House of the Spirits** *by Isabel Allende* **(1280L)**	**In the Shadow of Man** *by Jane Goodall* **(1220L)** **Fast Food Nation: The Dark Side of the All-American Meal** *by Eric Schlosser* **(1240L)** **Into the Wild** *by Jon Krakauer* **(1270L)**
1300L	**Eight Tales of Terror** *by Edgar Allan Poe* **(1340L)** **The Metamorphosis** *by Franz Kafka* **(1320L)** **Silas Marner** *by George Eliot* **(1330L)**	**Common Sense** *by Thomas Paine* **(1330L)** **Never Cry Wolf** *by Farley Mowat* **(1330L)** **The Life and Times of Frederick Douglass** *by Frederick Douglass* **(1400L)**

Appendix B: Fall Norm Tables

Fall scores based on a norming study performed by MetaMetrics to determine a baseline for growth.

Fall Percentile	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
1	BR	BR	BR	BR	50	160
5	BR	BR	75	225	350	425
10	BR	BR	160	295	430	490
25	BR	115	360	470	610	670
35	BR	200	455	560	695	760
50	BR	310	550	670	795	845
65	BR	425	645	770	875	925
75	BR	520	715	835	945	985
90	105	650	850	960	1060	1095
95	205	750	945	1030	1125	1180

Fall Percentile	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
1	210	285	380	415	455	460
5	510	550	655	670	720	745
10	590	630	720	735	780	805
25	760	815	865	880	930	945
35	825	885	935	906	995	1010
50	910	970	1015	1045	1080	1090
65	985	1045	1095	1125	1155	1165
75	1050	1105	1150	1180	1205	1215
90	1160	1210	1260	1290	1315	1325
95	1245	1295	1345	1365	1390	1405

Appendix B: Spring Norm Tables

Spring scores based on a norming study performed by MetaMetrics to determine a baseline for growth.

Spring Percentile	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
1	BR	BR	BR	BR	BR	190
5	BR	BR	125	255	390	455
10	BR	BR	210	325	475	525
25	BR	275	390	505	630	700
35	BR	400	480	595	710	775
50	150	475	590	700	810	880
65	270	575	690	800	905	975
75	345	645	755	865	970	1035
90	550	780	890	990	1085	1155
95	635	870	965	1060	1155	1220

Spring Percentile	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11	Grade 12
1	240	295	400	435	465	465
5	545	560	670	720	745	755
10	625	645	730	780	810	820
25	780	835	880	930	945	955
35	860	905	960	995	1010	1020
50	955	1000	1045	1080	1090	1100
65	1040	1090	1125	1155	1165	1175
75	1095	1145	1180	1205	1215	1225
90	1210	1265	1290	1320	1330	1340
95	1270	1330	1365	1390	1405	1415

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