Formative Assessment System for Teachers™ (FAST™)

Abbreviated Technical Manual for Iowa
Version 2.0, 2015–2016

NOTICE: Information for measures that were not implemented statewide is omitted from this publication at the request of The Iowa Department of Education.

Research to Results™

FastBridge Learning, LLC
43 Main Street SE, Ste. 509
Minneapolis, MN 55414
612-424-3714
info@fastbridge.org
FastBridge.org

Formative Assessment System for Teachers™ (FAST™): Abridged Technical Manual
Version for Iowa 2.0

Published by Theodore J. Christ and Colleagues, LLC (TJCC)

Distributed by TJCC and FastBridge Learning, LLC (FBL)

43 Main Street SE Suite # 509
Minneapolis, MN 55414
Email: help@fastbridge.org
Website: www.fastbridge.org
Phone: 612-424-3714

Prepared by Theodore J. Christ, PhD as Senior Author and Editor with contributions from (alphabetic order) Yvette Anne Arañas, MA; LeAnne Johnson, PhD; Jessie M. Kember, MA; Stephen Kilgus, PhD; Allyson J. Kiss; Allison M. McCarthy Trentman, PhD; Barbara D. Monaghen PhD; Gena Nelson, MA; Peter Nelson, PhD; Kirsten W. Newell, MA; Ethan R. Van Norman, PhD; Mary Jane White, PhD; and Holly Windram, PhD as Associate Authors and Editors.

Citation:
Theodore J. Christ and Colleagues (2015). Formative Assessment System for Teachers: Abbreviated Technical Manual for Iowa Version 2.0, Minneapolis, MN: Author and FastBridge Learning (www.fastbridge.org)

Forward

Our Story

Over 15 years, our research team received competitive funding from the US Department of Education to build knowledge and improve educational assessments. The Formative Assessment System for Teachers™ (FAST™) is how we disseminate that work. It was developed to reduce the gap between research at universities and results in the classroom, which can take 10 to 30 years in a typical cycle. FAST™ has reduced that to weeks or months. We innovate today and implement tomorrow.

In 2010, Dr. Zoheb H. Borbora (Co-Founder) and I (Founder) conceptualized and created FAST™ as a cloud-based system at the University of Minnesota. Our goal was to use research and technology to make it easier for teachers to collect and use data to improve student outcomes. We initially tried to create and distribute for free. That model was unsustainable. We had no resources to achieve our standard of excellence. The school leadership and teachers that were our partners preferred an excellent low-cost system over a good free system. With the University, we made this transition in early 2012. The demand for FAST™ was tremendous and overwhelming. The demand quickly outpaced what we could support at the University. So, FastBridge Learning was launched in the spring of 2015 to distribute and support FAST™.

FastBridge Learning is a partnership between the University of Minnesota, "Theodore J. Christ and Colleagues" (TJCC), and the FAST™ team. In 2014–15, FAST™ was used in more than 30 states, which includes a statewide adoption in Iowa (92% of schools). FAST™ users exceeded 5 million administrations in 2014–15. The feedback has been tremendous. In partnership, we continue to strive for our vision: **Research to Results™**.

Our Mission

The University of Minnesota and TJCC continue with their mission to innovate with research and development. FastBridge Learning continues to translate those innovations into practice for use by teachers. We aspire to provide a seamless and fully integrated solution for PreK–12 teaching, learning, and assessment. We are not just about assessment. We are about learning and optimization of teaching, parenting, and being. FAST™ was the centerpiece of FastBridge Learning in 2014–15. It will soon be supplemented with teaching and learning tools (e.g., materials, guides, reports, and automated software-based personalized instruction).

Like-minded researchers and trainers are encouraged to join our cause (ted@fastbridge.org, www.fastbridge.org). Educators are invited to join FastBridge Learning and challenge us to innovate and deliver solutions for the most challenging teaching and learning problems.

Our Values

We are values driven. We strive towards our values. Those are: **Tell the Truth, Respect the Teacher, and Deliver High-Value Solutions**. These values inform our work, and we measure our successes against them. We invite others to hold us accountable.

We Tell the Truth

Perhaps more than at any time in the past, educators are bombarded with claims of research, evidence, data, statistics, and assessments. These words relate to very important and lofty subject matter that is undermined when they are misused or abused for marketing, sales, or self-promotion. We strive to know better and do better. We strive to tell the truth. And, the truth is that all research has its limitations, as do the various types of assessment and data. That is true regardless of any misleading claims. So, we acknowledge the limitations of the tools we deliver, and we do not exaggerate our claims. Instead, we deliver multiple types of assessment in one suite and provide guidance so users **use the right tool for the right purpose**. It is an honest and better solution for teachers.

We Respect the Teacher

At the beginning, FAST™ (Formative Assessment System for Teachers) was named to make the value of teachers explicit. They are the primary intended user so we include them and value their opinions that guide our research, development and refinement. We are in service to the professional educator. We aspire to make their work easier and more effective.

I (Dr. Christ) was a paraprofessional, residential counselor, and special education teacher. I earned my MA and PhD degrees in school psychology as part of my professional development to be a better teacher for students who are at risk. I always intended to return to the classroom but was drawn into a research career, which gives me great joy. Our team respects, responds, and solicits input from teachers who work to solve difficult problems with limited resources. We try to understand and meet their needs—and yours—with quality research, engineering, training, and support.

We Deliver High-Value Solutions

We strive to provide systems and services that are effective, efficient, elegant and economical.

- An **effective** solution improves child outcomes.
- An **efficient** solution saves time and resources.
- An **elegant** solution is pleasing and easy to use.
- An **economical** solution is sustainable for us and our users.

Design and user focus are central tenets.

Final Note from Dr. Christ

Thank you for considering our work. It is a compilation of efforts by many graduate and undergraduate students, researchers, teachers, principals, and state agencies. This would not exist without them. I am very thankful for their contributions. I hope it confers great benefit to the professional educator and the children they serve. Education has the potential to be the great equalizer and reduce the gaps in opportunity and achievement; however, we will only realize that potential if education is of high and equitable quality. I hope we help in the pursuit of that.

Sincerely,
Ted

Theodore J. Christ, PhD
Co-Founder and Chief Scientific Officer

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Section 1. Introduction to FAST™ and FastBridge Learning

This document provides a brief overview of FastBridge Learning and a detailed description of the Formative Assessment System for Teachers™ (FAST™) measures. This document is partitioned into six major sections:

- Introduction to FAST™ and FastBridge Learning
- Reading Measures
- Math Measures
- Social-Emotional-Behavioral Measures
- Early Childhood and School Readiness
- FAST™ as Evidence-Based Practice

The introduction and measurement sections are organized into chapters: (1) Overview, Purpose, and Description, (2) Development, (3) Administration and Scoring, (4) Interpretation of Test Results, (5) Reliability, (6) Validation, and (7) Diagnostic Accuracy of Benchmarks.

Chapter 1.1: Overview, Purpose, and Description

FAST™ was developed by researchers as a cloud-based system for teachers and educators.

Background

FAST™ assessments were developed by researchers at universities from around the country, which include the Universities of Minnesota, Georgia, Syracuse, East Carolina, Buffalo, Temple, and Missouri. FAST™ cloud-based technology was developed to support the use of those assessments for learning. Although there is a broad set of potential uses, the system was initially conceptualized to make it easier for teachers (see the Forward for more information).

FAST™ is designed for use within Multi-Tiered Systems of Support (MTSS) and Response to Intervention (RTI) frameworks for early intervention and prevention of deficits and disabilities. It is research- and evidence-based. FAST™ is distinguished and trusted by educators. It is transforming teaching and learning for educators and kids nationwide.

All in One

FAST™ is one, comprehensive, simple cloud-based system with Curriculum-Based Measurement (CBM) and Computer-Adaptive Tests (CAT) for universal screening, progress monitoring, MTSS/RTI support, online scoring, and automated reporting. It is easy to implement with online training and resources, automated rostering and SIS integration, nothing to install or maintain, and multi-platform and device support.

Research to Results™

Support and Training

Our school support team is accessible and responsive for support via live chat, e-mail, or phone. When combined with our knowledge base—full of quick tips, articles, videos, webinars, and flipped training for staff—in addition to customized online or onsite training, your teachers and administration are supported at every step.

Trusted Results

FAST™ is an evidence-based formative assessment system that was developed by researchers at the University of Minnesota in cooperation with others from around the country. They set out to offer teachers an easier way to access and use the highest quality formative assessments. Researchers and developers are continuously engaged with teachers and other users to refine and develop the best solutions for them. (e.g., better data, automated assessments, and sensible reports).

Curriculum-Based Measurement (CBM)

Our Curriculum-Based Measures (CBM) are highly sensitive to growth over brief periods. We offer Common Core-aligned CBM measures with online scoring and automated skills analysis in earlyReading and earlyMath (K-1), CBMreading, CBMcomprehension, and CBMmath (1-6).

Automated Assessments

Our Computer-Adaptive Tests (CAT) provide a reliable measure of broad achievement and predict high-stakes test outcomes with high accuracy. Automatically adapting to students' skill levels to inform instruction and identify MTSS/RtI grouping, we offer aReading (K–12), aMath (K–6), and Standards-Based Math (6–8).

Prevention and Intervention

Designed for Multi-Tiered Systems of Support (MTSS) and Response to Intervention (RTI), FAST™ makes program implementation easy and efficient with automated scoring, analysis, norming and reporting; customizable screening, benchmarking, instructional recommendations, and progress monitoring.

Chapter 1.2: Development

FastBridge Learning has a strong foundation in both research and theory. FAST™ assessments were created to provide a general estimate of overall achievement in reading and math, as well as provide a tool to identify students at risk for emotional and behavioral problems. For reading and math assessments, item banks have been created containing a variety of items, including those with pictures, words, individual letters and letter sounds, sentences, paragraphs, and combinations of these elements. Overall, FastBridge Learning aims to extend and improve on the quality of currently available assessments.

Chapter 1.3: Administration and Scoring

FAST™ is supported by an extensive set of materials to support teachers and students, including self-directed training modules that allow teachers to become certified to administer each of the assessments. FAST™ assessments can be administered by classroom teachers, special education teachers, school psychologists, and other individuals such as paraprofessionals with usually less than an hour of training. Administration time varies depending on which assessment is being administered. Online administrations require a hard copy of the student materials (one copy per student) and access to the FAST™ system (i.e., iPad or computer with Internet connection). Paper-and-pencil assessment administration materials and instructions are available upon request. As with any assessment, only students who can understand the instructions and can make the necessary responses should be administered FAST™ assessments. Assessments should be administered in a quiet area conducive to optimal performance. The brevity of FAST™ assessments aims to minimize examinee fatigue, anxiety, and inattention. For the majority of assessments, FAST™ produces automated reports summarizing raw scores, percentile scores, developmental benchmarks, subscale and subtest scores, and composite scores. The online system provides standardized directions and instructions for the assessment administrator.

Setting Standards

Overall, FastBridge Learning uses standard-setting processes to summarize student performance. Standards may be used to inform goal setting, identify instructional level, and evaluate the accuracy of student performance. For the purpose of this technical manual, standards are the content or skills that are expected (*content standards*), which are often defined by a score for purposes of measurement (*performance standards*). A number of terms are used to reference performance standards, including: benchmarks, cut scores, performance levels, frustrational, instructional or mastery levels, and thresholds. These terms each reference categories of performance with respect to standards and are used throughout the technical manual. The method of standard setting is described below.

Chapter 1.4: Interpretation of Test Results

The FastBridge Learning software provides various resources to assist administrators with test result interpretations. For example, a Visual Conventions drop down menu is available to facilitate interpretation of screening and progress monitoring group and individual reports. Percentiles are calculated for local school norms unless otherwise indicated. Local school norms compare individual student performances to their same grade and school peers. For example, a student in the 72nd percentile performed as well or better than 72 percent of his or her grade level peers at that school. Methods of notation are also included to provide information regarding those students predicted to be at risk. Exclamation marks (! and !!) indicate the level of risk based on national norms. One exclamation mark refers to some risk, whereas two exclamation marks refer to high risk of reading difficulties or not meeting statewide assessments benchmarks, based on the score. Interpreting FastBridge Learning assessment scores involves a basic understanding of the various scores provided in the FAST™ system and helps to guide instructional and intervention development. FAST™ includes individual, class, and grade level reports for screening, and individual reports for progress monitoring. Additionally, online training modules include sections on administering the assessments, interpreting results, screen casts, and videos.

Results should always be interpreted carefully considering reliability and validity of the score, which is influenced by the quality of standardized administration and scoring. It important to consider the intended purpose of the assessment, its content, the stability of performance over time, scoring procedures, testing situations, or the examinee. The FAST™ system automates analysis, scoring, calculations, reporting and data aggregation. It also facilitates scaling and equating across screening and progress monitoring occasions.

Standard Setting

It is necessary to address questions such as, "How much skill/ability defines proficiency?" There are many methods used for standards setting; however, human judgment is inherent to the process (Hambleton & Pitoniak, 2006) because some person(s) decide "how many" or "how much is enough" to meet a standard. Because judgment is involved, there are some criticisms that standard setting is arbitrary (Glass, 1978) and the results of standard setting are very often the source of debate and scrutiny. *The Standards for Educational and Psychological Testing* (AERA, APA & NCME, 199) define the basic requirements to set standards and therein recognize the role of human judgment: "cut scores embody value judgments as well as technical and empirical considerations" (p. 54). The standard setting process in designed to ensure those value judgments are well-informed. The *Standards* along with the professional literature (e.g., Hableton & Pitoniak, 2006; Swets, Dawes & Monahan, 2000) guide the standard setting processes for FAST™. A brief description of relevant concepts and methods are below.

Kane (1994, 2006, 2013) suggests that the rationale and reasons for the selected standard-setting procedure are often the most relevant and important source of evidence for the validity of standards to interpret scores. The method should be explicit, practical for the intended interpretation and use, implemented with fidelity, and documented (Hambleton & Pitoniak, 2006). The convergence of standards with other sources of information, such as criterion measures, also contributes to validation; however, such evidence is often limited because the quality and standards from external sources are often just as limited (Kane, 2001). Moreover, external sources, such as criterion measures, are often unavailable or misaligned with the experimental measure or intended use for the standard.

Standard Setting Methods

There are methods to set relative or absolute standards. *Norm-referenced* methods are most familiar to the general public. They are used to set a relative standard such that a particular proportion of a population is above or below the standard. For example, if the standard is set at the 40th percentile then 39% of the population is below and 60% is at or above. Norm-referenced standards are relative to the performances in the population. As noted by Sereci (2005), "scores are interpreted with respect to being better or worse than others, rather than with respect to the level of competence of a specific test taker" (p. 118). Norm-referenced standards are used in FAST™ to guide resource allocation. Grade-level norms are provided for the class, school, district, and nation.

Absolute- or criterion-referenced methods are less familiar to the general public. They are used to define "how much is enough" to be above or below a standard. For example, if the standard is that students should identify all of the letters in the alphabet with 100% accuracy then all of the students in a particular grade might be above or below that standard. These methods often rely on the judgment of experts who classify items, behaviors, or individual persons. Those judgments are used to define the standard. For example, the expert is asked to consider a person whose performance is just at the standard. They then estimate the probability that person would exhibit a particular behavior or response correctly to a particular item. Another approach is to have that expert classify individuals as above or below the standard. Once classified, the performance of the individuals is analyzed to define the standard. The particular method is carefully selected based on the content and purpose of the measure and standard. Careful selection of experts and panels, training, procedures, validation and documentation are all important components of those expert-based approaches.

Norm-Referenced Standards

Norm-referenced methods are used to set a relative standard such that a particular proportion of a population is above or below the standard. For example, if the standard is set at the 40th percentile then 39% of the population is below and 60% is at or above. Norm-referenced standards are relative to the performances in the population. As noted by Sereci (2005), "scores are interpreted with respect to being better or worse than others, rather than with respect to the level of competence of a specific test taker" (p. 118). Norm-referenced standards are used in FAST™ to guide resource allocation. Grade-level norms are provided for the class, school, district and nation.

Norm-Referenced Interpretations

FAST™ calculates and reports the percentile ranks, or percentiles, of scores relative to same-grade peer performance in the class, school, district, and FAST™ users around the nation. Those percentiles are classified and color-coded in bands: ≤ 19.99th (red), 20th to 29.99th (orange), 30th to 84.99th (green) and ≥ 85th percentiles (blue). These standards were set to guide resource allocations for early intervention and prevention within multi-tiered systems of support (MTSS).

Student name	Words Read Corrrect (WRC)			Percentile rank in grade Five (Spring)		
	Fall	Winter	Spring	At class	At school	At district
	181	193	211	99	95	92
Student A	185	215	207	92	89	89
	188	210	207	92	89	89
	161	176	193	88	77	81
	173	174	192	83	73	80
	165	177	191	79	72	79
	156	168	189	75	68	77
	171	175	188	71	66	75
	162	187	182	67	61	69
			177	63	53	64
	159	188	173	58	47	59
	118 !	155	164	54	43	48
	129	151	153	50	30	36
	113 !	144	152	46	29	34
	113 !	119 !	146	42	25	30
	117 !	137	144	38	23	29
Student B	96 ! !	106 ! !	139 !	33	20	25
	105 ! !	118 !	137 !	25	18	24
	121 !	129 !	137 !	25	18	24
	104 ! !	123 !	129 !	21	15	18
	94 ! !	122 !	125 !	17	11	15
	105 ! !	114 !	122 !	13	10	14
	97 ! !	112 ! !	121 !	8	9	14
	106 ! !	132	117 ! !	4	8	12
Student C	86 93% ! !	115 !	103 ! !	1	5	6

Visual conventions

Accuracy		Risk		Percentile ranks
90%	Less than 95%	!	Some risk	Above 85 percentile
		! !	High risk	30-85 percentile
				20-30 percentile
				Below 20 percentile

Most schools can provide supplemental and intensive supports for students at risk and enrichment for the highest achieving students. Schools rarely have resources to support more than 30% of at-risk learners with supplemental and intensive supports; even if a larger proportion would benefit (Christ, 2008; Christ & Arañas, 2014). The norm-referenced standards are applied to each norm group to support decisions by individual teachers (class norms), school-based grade level teams (school norms) and district-wide grade level teams (district norms) as to which students receive supports.

The percentiles and standards should be used to identify the individuals who will receive supplemental support. The proportion of the population who receive supports depends on the availability of resources. For example, one school might provide supplemental support to all students below the 30th percentile (red and orange). Another school might provide supplemental support to all students below the 20th percentile (red), but monitor those below the 30th percentile (orange). These are local decisions that should be determined in consideration of the balance between student needs and system resources.

National norms are used to compare local performance to that of an external group. The standards (color codes) are applied to support decisions about core and system-level supports. Visual analysis of color codes are useful to estimate the typicality of achievement in the local population. They are often used in combination with benchmarks to guide school and district level decisions about instruction, curriculum and system-wide services (e.g., are the school-wide core reading services sufficient to prevent deficit achievement for 80% of students). If FAST™ data indicate that much more than 20% of a school or district's students are below the 20th percentile on national norms, then remediation efforts in that area should be considered as the data suggest that the core instruction is not supporting adequate achievement. If they observe that fewer than 20% of the total school population are below the 20th percentile on national norms, their population is over-performing relative to others. Subsequently, the school should continue using effective services, but identify another domain of focus.

Criterion-Referenced Standards (Benchmarks)

Absolute or *criterion-referenced methods* are used to define "how much is enough" to be above or below a standard. For example, if the standard is that students should identify all of the letters in the alphabet with 100% accuracy then all of the students in a particular grade might be above or below that standard. These methods often rely on the judgment of experts who classify items, behaviors, or individual persons. Those judgments are used to define the standard. For example, the expert is asked to consider a person whose performance is just at the standard. They then estimate the probability that person would exhibit a particular behavior or response correctly to a particular item. Another approach is to have that expert classify individuals as above or below the standard. Once classified, the performance of the individuals is analyzed to define the standard. The particular method is carefully selected based on the content and purpose of the measure and standard. Careful selection of experts and panels, training, procedures, validation, and documentation are all important components of those expert-based approaches.

FAST™ reports provide tri-annual grade-level benchmarks, which generally correspond with the 15th and 40th percentiles on national norms. Scores below the 15th percentile are classified as "high-risk." Those at-or-above the 15th and below the 40th are "some risk;" and those at or above the 40th are "low risk." This is consistent with established procedures and published recommendations (e.g., RTI Network). It is common practice to use norm-reference standards at the 15th and 40th percentiles; or to use pre-determined standards on state achievement tests. As quoted from the RTI Network:

> *"Reading screens attempt to predict which students will score poorly on a future reading test (i.e., the criterion measure). Some schools use norm-referenced test scores for their criterion measure, defining poor reading by a score corresponding to a specific percentile (e.g., below the 10th, 15th, 25th, or 40th percentile). Others define poor reading according to a predetermined standard (e.g., scoring below "basic") on the state's proficiency test. The important point is that satisfactory and unsatisfactory reading outcomes are dichotomous (defined by a cut-point on a reading test given later in the students' career). Where this cut-point is set (e.g., the 10th or 40th percentile) and the specific criterion reading test used to define reading failure (e.g., a state test or SAT 10) greatly affects which students a screen seeks to identify"*
> (retrieved on 1-24-15 from http://www.rtinetwork.org/essential/assessment/screening/readingproblems)

The procedure used by FAST™ is described in more detail below. Again, FAST™ establishes benchmarks that approximate the 15th and 40th percentiles on national norms. This report provides additional evidence on the correspondence with those standards and proficiency on state tests.

Interpreting Criterion-Referenced Standards

Benchmarks are often used to discern whether students are likely to perform sufficiently on a high-stakes assessment, such as a state test. FastBridge Learning will estimate specific benchmarks for states and districts if their state test data are provided (help@fastbridge.org). Another way to interpret benchmarks is to consider them the minimal level of performance that is acceptable. Anything less places the student at risk. These standards should be met for all students. They are not based on the distribution of performance unlike norms so *all* students can truly meet benchmark standards.

If more than 30% of students are below the "some risk" benchmark standard, then it is necessary to modify core instruction and general education instruction to better serve all students. This is the most efficient approach to remediate widespread deficits. If fewer than 15% of are below the "some risk" benchmark standard in a specific content area, then core instruction is highly effective. It should be maintained and other content areas should be considered the focus. Schools often focus on reading and behavior and then move to math and other content areas as they achieve benchmark standards for 85% of students in each domain.

Chapter 1.5: Reliability

Reliability refers to the stability with which a test measures the same skills across minimal differences in circumstances. Nunnally and Bernstein (1994) offer a hierarchical framework for estimating the reliability of a test, emphasizing the documentation of several forms of reliability. First and foremost, alternate-form reliability with a two-week interval is recommended, assuming that alternate (but equivalent) forms of the same test with different items should produce approximate scores. The second recommended form of reliability is test-retest reliability, which also employs a two-week interval of time. The same test administered at two different points in time (i.e., the difference of a two-week interval) should produce approximately the same scores. Finally, inter-rater reliability is recommended and may be evaluated by comparing scores obtained for the same student by two different examiners. For many FastBridge Learning assessments, there is no threat to inter-rater reliability because assessments are electronically scored. For the purpose of this technical manual, error refers to unintended factors that contribute to changes in scores. Other forms of reliability evidence include internal consistency (the extent to which different items measure the same general construct and produce similar scores), and reliability of the slope (the ratio of true score variance to total variance).

Overall, FastBridge Learning assessments show evidence of reliability coefficients that show promise for producing little test error. Further, evidence supports the use of FastBridge Learning measures for screening and progress monitoring, and for informing teachers of whether instructional practices have been effective or if more and what kind of instruction may be necessary to advance student growth in reading and math skills. Educators can be confident that the FastBridge Learning assessments provide meaningful instructional information that can be quickly and easily interpreted and applied to impact student learning. Current research on FastBridge Learning assessments is encouraging, suggesting that these assessments may be used to reliably differentiate between students who are or are not at risk for reading problems, math problems, or behavioral or emotional problems.

Chapter 1.6: Validity

To validate an interpretation or use of test scores is to evaluate the plausibility of the claims based on those scores (Kane, 2013). According to Kane (2013), interpretations and uses can change over time in response to evolving needs and new understandings. Additionally, consequences of the proposed uses of a test score need to be evaluated. Validity refers to the extent to which evidence and theory support the interpretations of test scores. Types of validity discussed in this technical manual are content, criterion, predictive, and discriminant validity.

Content validity is the extent to which a test's items represent the domain or universe intended to be measured. Criterion-related validity is the extent to which performance on a criterion measure can be estimated from performance on the assessment procedure being evaluated. Predictive validity is the extent to which performance on a criterion measure can be estimated from performance across time on the assessment being evaluated. Finally, discriminant validity is a measure of how well an assessment distinguishes between two groups of students at different skill levels.

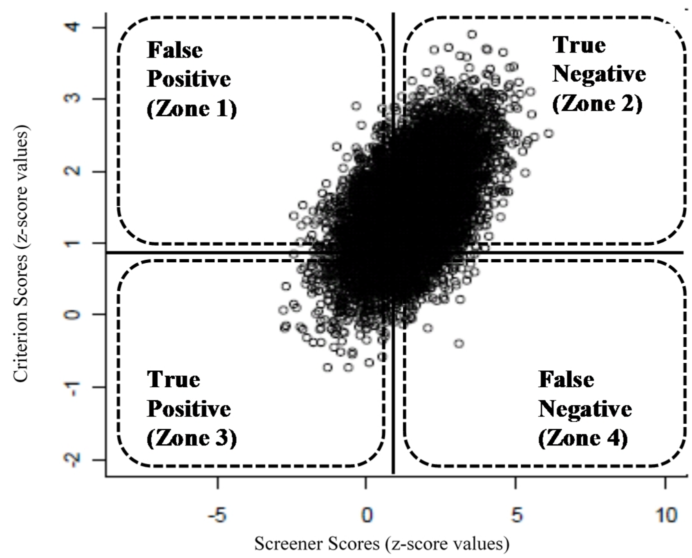
Establishing validity evidence of FastBridge Learning assessments is ongoing. Studies will continue to provide information regarding the content and construct validity of each assessment. Validity evidence will be interpreted as data is disaggregated across gender, racial, ethnic, and cultural groups. All FastBridge Learning assessments were designed to be sensitive to student growth while also providing instructionally relevant information. Current research supports the validity of FastBridge Learning assessments across reading, math, and behavioral domains.

Chapter 1.7: Diagnostic Accuracy of Benchmarks

Campbell and Ramey (1994) acknowledged the importance of early identification through the use of effective screening measures and intervention with those students in need. Early identification, screening, and intervention have been shown to improve academic and social-emotional/behavioral outcomes (Severson, Walker, Hope-DooLittle, Kratochwill, & Gresham, 2007). Effective screening is a pre-requisite for efficient service delivery in a multi-tiered Response to Intervention (RTI) framework (Jenkins, Hudson, & Johnson, 2007). RTI seeks to categorize students accurately as being at risk or not at risk for academic failure. Inaccurate categorization can lead to consequences such as ineffective allocation of already minimal resources.

A Conceptual Explanation: Diagnostic Accuracy of Screeners

Within medicine, a diagnostic test can be used to determine the presence or absence of a disease. The results of a screening device are compared with a "gold standard" of evidence. For instance, a doctor may administer an assessment testing whether a tumor is malignant or benign. Based on a gold standard, or later diagnosis, we can estimate how well the screener identifies cases in which the patient truly has the ailment and cases in which he or she does not. When using any diagnostic test with a gold standard there are four possible outcomes: the test classifies the tumor as malignant when in fact it is malignant (True Positive; TP), the test classifies the tumor as not malignant when in fact it is not malignant (True Negative; TN), the test classifies the tumor as malignant when in fact it is benign (False Positive; FP), and the test classifies the tumor as benign when in fact it is malignant (False Negative; FN). The rates of each classification are directly tied to the decision threshold, or cut-off score, of the screening measure. The cut-off score is the score at which a subject is said to be symptomatic or not symptomatic. The decision regarding placement of the decision threshold is directly tied to the implications of misclassifying a person as symptomatic versus not-symptomatic (Swets, Dawes, & Monahan, 2000). In the case of the tumor, a FN may mean that a patient does not undergo a lifesaving procedure. Conversely, a FP may cause undue stress and financial expense for treatments that aren't needed.



Decisions that Guide Benchmarks Selection: Early Intervention and Prevention

It should be apparent from a review of the illustration above that decisions based on the screener are inherently imperfect. The depiction in that particular figure illustrates a correlation of approximately .70 between the predictor and criterion measure. In this example, CBMreading is an imperfect predictor of performance on the state test. Regardless of the measures, there will always be an imperfect relationship. This is also true for test-retest and alternate-form reliability (i.e., performance on the same test on two occasions). Tests are inherently unreliable, and all interpretations of scores are tentative. This is especially true for screening assessments, which are designed to be highly efficient and, therefore, often have less reliability and validity than a more comprehensive, albeit inefficient, assessment.

For the purposes of screening in education, students who are in need of extra help may be overlooked (FN), and students who do not need extra help may receive unneeded services (FP). The performance of diagnostic tests, and corresponding decision thresholds, can be measured via sensitivity, specificity, positive predictive value, negative predictive value, and area under the curve (AUC). All of the following definitions are based on the work of Grzybowski and Younger (1997).

i. *Sensitivity*: The probability of a student testing positive given the true presence of a difficulty. (TP / TP + FN)
ii. *Specificity*: The probability of a student testing negative if the difficulty does not exist. (TN / TN + FP)
iii. *Positive Predictive Power*: The proportion of truly struggling students among those with positive test results. (TP / TP + FP)
i. *Negative Predictive Power*: The proportion of truly non-struggling students among all those with negative test results. (TN / TN + FN)
ii. *Area Under the Curve (AUC)*: Quantitative measure of the accuracy of a test in discriminating between students at-risk and not at-risk across all decision thresholds.

Previous research in school psychology (e.g., Hintze & Silberglitt, 2005; VanDerHeyden, 2011) derives decision thresholds by iteratively computing specificity and sensitivity at different cut scores. Precedence would be given to maximize each criterion by computing sensitivity and specificity for each point. A more psychometrically sound and efficient method is to compute scores via a receiver operating characteristic (ROC) curve analysis.

Area Under the Curve (AUC)

Area Under the Curve (AUC) is used as a measure of predictive power. It is obtained by calculating the sensitivity and specificity values for all possible cutoff points on the screener by fixing a cutoff point on criterion measure and plotting *specificity* (or TPP) against *sensitivity* (or TNP). AUC is expected to be .5 if the screener provided little or no information. AUC is expected to be 1 for a perfect diagnostic method to identify the students at risk correctly. Although the criteria that are applied to interpret AUCs are variable, values are considered excellent (.90 to 1.0), good (.80 to .89), fair (.70 to 79), or poor (≤ .69). It seems reasonable and generally consistent with the standards outlined by the National Center for Response to Intervention that an AUC of at least .85 is required for low-stakes decisions and that an AUC of at least .90 is required for high-stake decisions.

Decision Threshold: Benchmark

A decision threshold is established to maximize the benefits of the decision process relative to its costs (Swets, Dawes, & Monahan, 2000). That threshold is adjusted to establish a neutral, lenient, or strict classification criterion for the predictor. A neutral threshold will balance the proportion of TP and FP, although not all thresholds should be balanced. For example, screening measures for reading often over-identify students (increase the rate of TP as well as FP) to ensure that fewer positive cases are missed. This is a rational choice, because failure to identify TP outweighs the consequences of increased FP.

Thresholds that are more lenient (over-identify) increase sensitivity, thereby increasing the proportion of positive classifications (both TP and FP). Thresholds that are more strict (under-identify) increase specificity, thereby increasing the proportion of negative classifications (both TN and FN; Swets et al., 2000). The decision threshold is adjusted to obtain the optimal ratio of positive and negative classifications along with that of true and false classifications. For example, Silberglitt and Hintze (2005) systematically modified the CBMreading benchmark scores in Third Grade to optimize the cut score, which improved classification accuracy. In general, **FAST™ uses a procedure to balance sensitivity and specificity so that benchmarks neither over- nor under-identify individuals**.

FastBridge Learning assessments predict performance on state accountability tests, including tests administered in Iowa, Illinois, Vermont, Indiana, New York, Colorado, Minnesota, Georgia, Massachusetts, and Wisconsin. For diagnostic accuracy analyses, cut scores were selected by optimizing sensitivity at approximately .70, and then balancing it with specificity using methods presented by Silberglitt and Hintze (2005). Overall, **analyses suggest that current benchmarks for FastBridge Learning assessments are appropriate, accurate, and reliable**.

For a summary of Reading Diagnostic Accuracy statistics, see Appendix B: FastBridge Learning Reading Diagnostic Accuracy.

Section 2. Reading and Language

Chapter 2.1: Overview, Purpose, and Description

earlyReading

The earlyReading measure is designed to assess both unified and component skills associated with Kindergarten and First Grade reading achievement. earlyReading is intended to enable screening and progress monitoring across four domains of reading (Concepts of Print, Phonemic Awareness, Phonics, and Decoding) and provide domain-specific assessments of these component skills as well as a general estimate of overall reading achievement. earlyReading is an extension of CBMreading, which was initially developed by Deno and colleagues to index the level and rate of reading achievement (Deno, 1985; Shinn, 1989). The current version of earlyReading has an item bank that contains a variety of items, including those with pictures, words, individual letters and letter sounds, sentences, paragraphs, and combinations of these elements.

The research literature provides substantial guidance on instruction and assessment of alphabetic knowledge, phonemic awareness, and oral reading. The objective of earlyReading measures is to extend and improve on the quality of currently available assessments.

Aspects of Reading measured by earlyReading

Concepts of Print (COP)

COP is defined as the general understanding of how print works and how it can be used (Snow, Burns, & Griffin, 1998). Concepts of print is the set of skills used in the manipulation of text-based materials, which includes effective orientation of materials (directionality), page turning, identifying the beginning and ending of sentences, identifying words, as well as identifying letters, sentences, and sentence parts. Concepts of print are normally developed in the emergent literacy phase of development and enable the development of meaningful early reading skills: “Emergent literacy consists of skills, knowledge, and attitudes that are developmental precursors to conventional forms of reading and writing” (Whitehurst & Lonigan, 1998). These skills typically develop from preschool through the beginning of First Grade— with some more advanced skills that develop through Second Grade, such as understanding punctuation, standard spelling, reversible words, sequence, and other standard conventions of written and spoken language. Introductory level of logical and analytical abilities as in understanding the concepts of print has an impact on early student reading achievement (Adams, 1990; Clay, 1972; Downing, Ollila, & Oliver, 1975; Hardy et al., 1974; Harlin & Lipa, 1990; Johns, 1972; Johns, 1980; Lomax & McGee, 1987; Nichols et al., 2004; Tumner et al., 1988).

Phonemic Awareness (PA)

Phonemic Awareness involves the ability to identify and manipulate phonemes in spoken words (National Reading Panel [NRP], 2000). Phonemes are the smallest units of sound in spoken language. "Depending on what distinctions are counted, there are between 36-44 phonemes in English, which is about average for languages" (Juel, 2006, p.418). According to Adams, “to the extent that children have learned to 'hear' phonemes as individual and separable speech sounds, the system will, through the associative network, strengthen their ability to remember or 'see' individual letters and spelling patterns" (1990, p. 304). Hearing and distinguishing individual letter sounds comes last (Goswami, 2000). Children who manipulate letters as they are learning to hear specific sounds have been shown to make better progress in early reading development than those who do not (NRP, 2000, p. 2-4). Phonemic awareness skills are centrally involved in decoding by processes of blending and segmenting phonemes (NRP, 2000). Phonemic awareness also helps children learn how to spell words correctly. Phonemic segmentation is required to help children retain correct spellings in memory by connecting graphemes (printed letters) to phonemes (NRP, 2000).

Phonics

Phonics is the set of skills readers use to identify and manipulate printed letters (graphemes) and sounds (phonemes). It is the correspondences between spoken and written language. This connection between letters, letter combinations, and sounds enable reading (decoding) and writing (encoding). Phonics skill development "involves learning the alphabetic system, that is, letter-sound correspondences and spelling patterns, and learning how to apply this knowledge" to reading (NRP, 2000b).

Decoding

"Decoding ability is developed through a progression of strategies sequential in nature: acquiring letter-sound knowledge, engaging in sequential decoding, decoding by recognizing word patterns, developing word accuracy in word recognition, and developing automaticity and fluency in word recognition" (Hiebert & Taylor, 2000, p. 467). When a child has a large and established visual lexicon of words in combination with effective strategies to decode unfamiliar words, he/she can read fluently—smoothly, quickly, and more efficiently (Adams, 1990; Snow et al., 1998). The reader can also focus his/her attention on monitoring comprehension: "If there are too many unknown words in the passage that require the child to apply more analytic (phonemic decoding) or guessing strategies to fill in the blanks, fluency will be impaired" (Phillips & Torgesen, 2006, p. 105). According to RAND, "readers with a slow or an inadequate mastery of word decoding may attempt to compensate by relying on meaning and context to drive comprehension, but at the cost of glossing over important details in the text" (2002, p. 104). Decoding is often linked with phonics with the emphasis on letter-sound knowledge. Vocabulary contains common characteristics with decoding such as recognizing word patterns, as in prefixes and suffixes.

Uses and Applications

earlyReading consists of 12 different evidence-based assessments for screening and monitoring student progress.

- Concepts of Print
- Onset Sounds
- Letter Names
- Letter Sounds
- Word Rhyming
- Word Blending
- Word Segmenting
- Decodable Words

- Nonsense Words
- Sight Words-Kindergarten (50 words)
- Sight Words-1st Grade (150 words)
- Sentence Reading
- Oral Language (Sentence Repetition)

There are recommended combinations of subtests for fall, winter, and spring screening aimed to optimize validity and risk evaluation. Similarly, there are recommended combinations of subtests for fall, winter, and spring for monitoring of progress. Supplemental assessments may be used to diagnose and evaluate skill deficits. Results from supplemental assessments provide guidance for instructional and intervention development. earlyReading is often used by teachers to screen all students and to estimate annual growth with tri-annual assessments (fall, winter, & spring). Students who progress at a typical pace through the reading curriculum meet the standards for expected performance at each point in the year. Students with deficit achievement can be identified in the fall of the academic year so that supplemental, differentiated, or individualized instruction can be provided.

earlyReading is designed to accommodate quick and easy weekly assessments, which provide useful data to monitor student progress and evaluate response to instruction. The availability of multiple alternate forms for various subtests of earlyReading make it suitable for monitoring progress between benchmark assessment intervals (i.e., fall, winter, and spring) for those students that require more frequent monitoring of progress. Onset Sounds has 13 alternate forms, and the following subtests have a total of 20 alternate forms: Letter Naming, Letter Sound, Word Blending, Word Segmenting, Decodable Words, Sight Words, and Nonsense Words. Concepts of Print, Rhyming, and Sentence Reading progress monitoring forms have not yet been developed.

Target Population

earlyReading is designed for all students in the early primary grade levels. This includes students in Kindergarten through Third Grade. earlyReading subtests are most relevant for students in Kindergarten and First Grade, but they have application to students in later grades who have yet to master early reading skills.

CBMreading

Curriculum-Based Measures of Reading (CBMreading) is a particular version of Curriculum-Based Measurement of Oral Reading fluency (CBM-R), which was originally developed by Deno and colleagues to index the level and rate of reading achievement (Deno, 1985; Shinn, 1989). The tool is an evidence-based assessment for use to screen and monitor student progress in reading competency in primary grades (1–6). CBMreading uses easy, time-efficient assessment procedures to determine a student's general reading ability across short intervals of time (i.e., weekly, monthly, or quarterly). Students read aloud for one minute from grade or instructional- level passages. The words read correct per minute (WRCM) functions as a robust indicator of a reading health and a sensitive indicator of intervention effects. CBMreading includes standardized administration and scoring procedures along with proprietary instrumentation, which was designed and developed to optimize the consistency of data collected across progress monitoring occasions. CBMreading provides teachers with a direct link to instruction and allows them to determine if and when instructional adaptations are needed, set ambitious but attainable goals for students, and monitor progress toward those goals (Fuchs & Fuchs, 2002).

CBMreading emerged from a project funded by the Institute for Education Sciences in the US Department of Education. That project was entitled *Formative Assessment Instrumentation and Procedures for Reading* (FAIP-R), so they are sometimes described as the FAIP-R passages. Early versions of those passages were used in published research (Ardoin & Christ, 2008; Christ & Ardoin, 2009). The goal in creating the CBMreading measures was to systematically develop, evaluate and finalize research-based instrumentation and procedures for accurate, reliable, and valid assessment and evaluation of reading rate.

For the remainder of the manual, CBM-R will refer to the general concept of Curriculum-Based Measurement of Oral Reading while CBMreading will refer to the assessment in FastBridge Learning.

Aspects of Reading Measured by CBMreading

The Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science and Technical Subjects (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) is a synthesis of information gathered from state departments of education, assessment developers, parents, students, educators, and other pertinent sources to develop the next generation of state standards of K–12 students to ensure that all students are college and career literacy ready by the end of their high school education. This process is headed by the Council of Chief State School Officers (CCSO) and the National Governors Association (NGA). The Standards are an extension of a previous initiative by the CCSSO and NGA titled the College and Career Readiness (CCR) Anchor Standards. The CCR Anchor Standards are numbered from one to ten. The Standards related to fluency are found within Foundational Skills in Reading. These standards are relevant to K–5 children and include the working knowledge of the following subcategories:

(1) Print Concepts: the ability to demonstrate the organization and basic feature of print.
(2) Phonological Awareness: demonstrate understanding of spoken words, syllables, and sounds or phonemes.
(3) Phonics and Word Recognition: the skill of applying grade-level phonics and word analysis skills in decoding words.
(4) Fluency: Reading on-level texts with sufficient purpose, accuracy, and fluency to support comprehension.

Oral Reading Fluency

Reading involves simultaneous completion of various component processes. In order to achieve simultaneous coordination across these component processes, instantaneous execution of each component skill is required (Logan, 1997). Reading fluency is achieved so that performance is speeded, effortless, autonomous, and achieved without much conscious awareness (Logan, 1997). Oral reading fluency represents the automatic translation of letters into coherent sound representations, unitizing those sound components into recognizable wholes, and automatically accessing lexical representations, processing meaningful connections within and between sentences, relating text meaning to prior information, and making inferences in order to supply missing information. Logan (1997) described oral reading fluency as the complex orchestration of these skills, establishing it as a reliable measure of reading expertise.

As previously mentioned, CBMreading is a particular version of an oral reading fluency measure. CBMreading is an effective tool used to measure rate of reading. Indeed, reading disabilities are most frequently associated with deficits in accurate and efficient word identification. Although reading is not merely rapid word identification or the "barking at words" (Samuels, 2007), the use of rate-based measures provide a general measure of reading that can alert teachers to students who have problems and are behind their peers in general reading ability. Overall, CBMreading provides a global indicator of reading.

Uses and Applications

CBMreading is an evidence-based assessment for use to screen and monitor students' progress in reading achievement in the primary grades (1–6). Each assessment is designed to be highly efficient and give a broad indication of reading competence. The automated output of each assessment gives information on the accuracy and fluency of passage reading which can be used to determine instructional level to inform intervention. At the school level, student growth can be tracked and monitored, allowing administrators to look at improvements both across grades and academic years for the purpose of accountability. Teachers and administrators may use this information to help parents better understand their children's reading needs.

Target Population

CBMreading is designed for all students in grades 1 through 6. For elementary grades 2 through 6, measures of fluency with connected text (curriculum-based measure of oral reading; CBM-R) are often used as a universal screeners for grade-level reading proficiency. Although strong evidence exists in the literature to support the use of CBM-R (Fuchs, Fuchs, & Maxwell, 1988; Kranzler, Brownell, & Miller, 1998; Markell & Deno, 1997), support for CBM-R as a universal screener for students who are not yet reading connected text is less robust (Fuchs, Fuchs, & Compton, 2004; National Research Council, 1998). Thus, CBMreading may not be appropriate for students not yet reading connected text with some degree of fluency. For those students not yet reading connected text with fluency, CBMreading results and scores should be interpreted with caution.

aReading

The Adaptive Reading (aReading) assessment is a computer-adaptive measure of broad reading ability that is individualized for each student. aReading provides a useful estimate of broad reading achievement from Kindergarten through twelfth grade. The question-and-response format used in aReading is substantially similar to many statewide, standardized assessments. Browser-based software adapts and individualizes the assessment for each child so that it essentially functions at the child's developmental and skill level. The adaptive nature of the test makes it more efficient and more precise than paper-and-pencil assessments.

The design of aReading has a strong foundation in both research and theory. During the early phases of student reading development, the component processes of reading are most predictive of future reading success (Stanovich, 1981, 1984, 1990; Vellutino & Scanlon, 1987, 1991; Vellutino, Scanlon, Small, & Tanzman, 1991). Indeed, reading disabilities are most frequently associated with deficits in accurate and efficient word identification. Those skills are necessary but not sufficient for reading to occur. After all, reading is comprehending and acquiring information through print. It is not merely rapid word identification or the "barking at words" (Samuels, 2007). As such, a unified reading construct is necessary to enhance the validity of reading assessment and inform balanced instruction throughout the elementary grades. aReading was developed based on a skills hierarchy and unified reading construct (presented later in the technical manual).

Computer-Adaptive Testing (CAT)

Classroom assessment practices have yet to benefit from advancements in both psychometric theory and computer technology. Today, almost every school and classroom in the United States provides access to computers and the Internet. Despite this improved access to computer technology, few educators use technology to its potential. Within an IRT based Computer-Adaptive Test (CAT), items are selected based on the student's performance on all previously administered items. As a student answers each item, the item is scored in real time, and his or her ability (theta) is estimated. When a CAT is first administered, items are selected via a "step rule" (Weiss, 2004). That is, if a student answers an initial item correctly, his or her theta estimate increases by some value (e.g., .50). Conversely, if an item is answered incorrectly, the student's theta estimate decreases by that same amount. As testing continues, the student's ability is re-estimated, typically via Maximum Likelihood Estimation (MLE).

After an item is administered and scored, theta is re-estimated and used to select the subsequent item. Items that provide the most information—based on the item information function—at that theta level that have not yet been administered are selected for the examinee to complete. The test is terminated after a specific number of items have been administered (a fixed-length test) or after a certain level of precision—measured by the standard error of the estimate of theta—is achieved. Subsequent administrations begin at the previous theta estimate and only present items that have not been administered to that particular student. Research using simulation methods and live data collections has been performed on aReading to optimize the length of administrations, the level of the initial step size, and item selection algorithms to maximize the efficiency, and psychometric properties of the assessment.

There are multiple benefits of CAT as compared to traditional paper-and-pencil tests or non-adaptive computerized tests. The benefits that are most often cited in the professional literature include: (a) individualized dynamic assessment, which does not rely on a fixed set of items across administrations/individuals; (b) testing time that is reduced by one-half to one-third (or more) of traditional tests because irrelevant items are excluded from the administration; (c) test applicability and measurement precision across a broad range of skills/abilities, and (d) more precise methods to equate assessment outcomes across alternate forms or administrations (Kingsbury & Houser, 1999; Weiss, 2004; Zickar, Overton, Taylor, & Harms, 1999).

IRT-based CAT can be especially useful in measuring change over time. CAT applications that are used to measure change/progress have been defined as adaptive self-referenced tests (Weiss, 2004; Weiss & Kingsbury, 1984) or, more recently, adaptive measurement of change (AMC; Kim-Kang & Weiss, 2007; Kim-Kang, & Weiss, 2008). AMCs can be used to measure the change of an individual's skills/abilities with repeated CATs administered from a common item bank. Since AMC is a CAT based in IRT, it eliminates most of the problems that result when measuring change (e.g., academic growth) using traditional assessment methods that are based in classical test theory. Kim-Kang and Weiss (2007) have demonstrated that change scores derived from AMC do not have the undesirable properties that are characteristic of change scores derived by classical testing methods. Research suggests that longitudinal measurements obtained from AMC have the potential to be sensitive to the effects of treatments and interventions at the single-person level, and are generally superior measures of change when compared to assessments developed within a classical test theory framework (VanLoy, 1996). Finally, AMC compiles data and performance estimates (θ) from across administrations to enhance the adaptivity and efficiency of CAT.

Aspects of Reading measured by aReading

Concepts of Print (COP)

The assessment of Concepts of Print in aReading focuses on assessing types of instruction outlined in the state and national standards and is based on relevant reading research for developing readers including skills synthesized from the work of Marie Clay (e.g., 2007), Barbara Taylor (i.e., 2011), Levy et al., (2006), and NWEA goals for Concepts of Print development (2009).

Concepts of Print is defined as the general understanding of how print works and how it can be used (Snow, Burns, & Griffin, 1998). Concepts of print is the set of skills used in the manipulation of text-based materials, which include effective orientation of materials (directionality), page turning, identify the beginning and ending of sentences, identify words, identify letters, sentences, and sentence parts.

Concepts of print are normally developed in the emergent literacy phase of development and enable the development of meaningful early reading skills: "Emergent literacy consists of skills, knowledge, and attitudes that are developmental precursors to conventional forms of reading and writing" (Whitehurst & Lonigan, 1998). These skills typically occur prior to or early in school years and are based on the child's exposure to printed materials and reading skills modeled by others, especially adults. Development in this area from age 4 to age 6 has been documented using word and sentence discrimination tasks that violated elements of word shape, word elements, and spelling (Levy, Gong, Hessels, Evans, & Jared, 2006).

By age 4, few children are able to read any single words, but most can distinguish drawings from writing and can detect abstract print elements such as letter spacing. These latter skills are related to letter reading skill but not phonological awareness. This suggests that print conventions may develop before word reading skills (Rayner, et al., 2012).

At age 5, most can detect word-shape and letter-orientation violations and letter sequencing. At age 6, knowledge of spelling is a stronger predictor of word reading than for 5 year olds (Rayner et al., 2012). According to Levy et al., "The data show clear development of print concepts from 48 to 83 months of age. This development begins with an understanding of figural and spatial aspects of writing (word shape). Next, or in conjunction with the first development, comes development of more abstract notions of word constituents, including letter orientation, and finally comes an understanding of more detailed aspects of acceptable spelling patterns" (2006, p. 89).

Some more advanced skills can develop through Second Grade, such as understanding punctuation, standard spelling, reversible words, sequence, and other standard conventions of written and spoken language. Introductory level of logical and analytical abilities as in understanding the concepts of print has an impact on early student reading achievement (Adams, 1990; Clay, 1972; Downing, Ollila, & Oliver, 1975; Hardy et al., 1974; Harlin & Lipa, 1990; Johns, 1972; Johns, 1980; Lomax & McGee, 1987; Nichols et al., 2004; Tumner et al., 1988).

Phonological Awareness (PA)

The assessment of Phonological Awareness in aReading focuses on assessing types of instruction outlined in the state and national standards and is based on relevant reading research for developing readers including skills that are *generally* ordered from broader segments of word sounds to smaller sound distinctions and the ability to manipulate these smaller sounds.

Phonological Awareness is a broad term involving the ability to detect and manipulate the sound structure of a language at the level of phonemes (i.e., smallest units of sound in spoken language), onset-rimes, syllables, and rhymes. It is used to refer to spoken language rather than letter-sound relationships, which are the focus of phonics. Most students, especially in preschool, Kindergarten, and First Grade, benefit from systematic and explicit instruction in this area (Adams, 1990; Carnine et al., 2009; NRP, 2000; Rayner et al., 2012; Snow, et al., 1998).

Phonemic awareness refers to the ability to know, think about, and use phonemes—individual sounds in spoken words. It is a specific type of phonological skill dealing with individual speech sounds that has been studied extensively and predicts success in reading development in languages that use alphabetic writing systems (Adams, 1990; NRP, 2000; Rayner, et al., 2012). The conscious awareness of phonemes as the basic units of sound in a language allows the reader to identify, segment, store, and manipulate phonemes in spoken words and it is required for proficient reading—when phonemes are linked to letters and letter combinations in the language's orthography. According to Adams, "to the extent that children have learned to 'hear' phonemes as individual and separable speech sounds, the system will, through an associative network, strengthen their ability to remember or 'see' individual letters and spelling patterns" (1990, p. 304). Unfortunately, this is a difficult task because the English language does not follow an explicit one-to-one correspondence between phonemes and letters (graphemes). English phonemes may be associated with various letters. Similarly, a single letter may be associated with several phonemes. This lack of one-to-one correspondence between phonemes and graphemes creates a sense of ambiguity. Although the English alphabet is generally structured so that many morphemes and words can be generated from relatively few letters (see Perfetti, 1985), the simplicity of the grapheme-phoneme relations in English (i.e., 26 letters to 41 phonemes—across numerous word combinations, letters or letter combinations with multiple sounds) makes it a less-transparent system for learners to decode phonologically (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967; Rayner et al., 2012). Rayner et al., (2012), provides a good example of this lack of transparency, "American English has over a dozen vowel sounds but only five standard vowel letters. That means that *a, e, i, o,* and *u* have to do double and triple duty…For example, *cat, cake, car, and call* each use the letter *a* for a different vowel phoneme" (2012, p.311).

Hearing and distinguishing individual letter sounds comes later in development (Goswami, 2000). Children who manipulate letters as they are learning to hear the sounds make better progress in early reading development (NRP, 2000, p. 2-4). Phonemic awareness skills are centrally involved in decoding by blending and segmenting phonemes (NRP, 2000). Phonemic awareness also helps children learn how to spell words correctly. Phonemic segmentation is required to help children retain correct spellings in memory by connecting graphemes to phonemes (NRP, 2000).

Phonics

The assessment of phonics in aReading focuses on assessing types of instruction outlined in the state and national standards and is based on relevant reading research about a student's ability to identify and manipulate printed letters (graphemes) and sounds (phonemes).

The correspondences between spoken and written language. This connection between letters, letter combinations, and sounds enable reading (decoding) and writing (encoding). Phonic skill development "involves learning the alphabetic system, that is, letter-sound correspondences and spelling patterns, and learning how to apply this knowledge" to reading (NRP, 2-89).

Phonics most often refers to an instructional approach—a systematic, planned, explicit, sequential method to teach beginning readers how to link written letters in words to the sounds of those letters (i.e., understand the alphabetic principle) to decode regular words. This instruction is helpful to most beginning readers in early primary grades (Christensen & Bowey, 2005; Juel & Minden-Cupp, 2000: Mathes et al., 2005; NRP, 2000; Stahl, 2001) and helps "…foster full alphabetic processing to enable children to handle the orthography" (Juel, 2006, p. 422). Indeed, early and systematic instruction in phonics results in better achievement in reading (; NRP, 2000; and others).

For the purpose of aReading assessment, we operationalize phonics as skills associated with the awareness and use of letter-sound (i.e., grapheme-phoneme) correspondence in relation to development of successful spelling and reading using the language's orthography. Assessment and instruction of phonics explores how these skills are applied to decode (read) and encode (spell/write) the language (NRP, 2000).

Orthography and Morphology

The assessment of orthography and morphology in aReading focuses on assessing types of instruction outlined in the state and national standards and is based on relevant reading research for readers including development of correct spelling, word identification and discrimination, and application of morphological and phonological knowledge.

Measures of orthography and morphology assist readers to recognize and decode or decipher words in isolation and during reading. The ability to quickly recognize words and access their meanings allows readers to focus their limited cognitive resources (e.g., attention, memory) on meaning instead of decoding (e.g., Bear, Invernizzi, Templeton, & Johnston, 2012). For example, students whose reading difficulties or disabilities persist into the secondary grades need explicit instruction in word recognition skills to help them identify and understand new words—particularly across different content areas. These skills contribute substantively to vocabulary and reading comprehension development, therefore assessing students in these areas allows aReading to determine if a student is able to accurately use and apply these skills.

Orthography

Orthography is the relationship between a script (i.e., a set of symbols) and the structure of a language (Katz & Frost, 1992). It typically refers to the use of letters and sounds to depict (i.e., write) a language. In relation to word learning and vocabulary development however, it refers to the reader's ability to identify, develop, store and retrieve orthographic representations of words or word parts using underlying *orthographic/visual* representations and *phonological* structures (Burt, 2006; Perfetti, 1992, 1997; Stanovich & West, 1989). Although phonological elements have been identified as central to development of letter and word skills, they do not explain all of the variance in word recognition such that, as Stanovich and West (1989) point out, "…phonological sensitivity is a necessary but not sufficient condition for the development of word recognition processes" (p.404). Thus the underlying visual element of orthographic representation is also important. Given older students' exposure to new words throughout the upper grade levels, *both* elements of sound and orthographic/visual representations of letter/word identification need to be considered when discussing assessment of orthography in older students.

Measures of orthography and morphology can assist readers in recognizing and decoding or deciphering words in isolation and during reading. The ability to quickly recognize words and access their meanings allows readers to focus their limited cognitive resources (e.g., attention, memory) on meaning instead of decoding (Bear et al., 2012). Students whose reading difficulties persist into the secondary grades need explicit instruction in word recognition skills to help them identify and understand new words – particularly across different content areas. These skills contribute substantively to vocabulary and reading comprehension development. Therefore, assessing students in these areas using aReading orthography items helps to determine whether a student is able to accurately use and apply these skills.

Morphology

Morphology is unique from orthography because it emphasizes recognition and manipulation of word parts that help readers better understand a word's meaning. Morphemes are the smallest unit of meaning in a word and morphology is the study of these forms or parts of words. In relation to word learning and vocabulary development, morphology refers to the reader's ability to be morphologically aware of word roots and affixes—suffixes and prefixes—and word origins (etymology). It also refers to the structural analysis readers may use to segment and manipulate parts of words to identify new words and help determine unknown word meanings (i.e., morphological analysis) (Carnine et al., 2009).

Morphological awareness is formally defined as "…awareness of morphemic structures of words and the ability to reflect on and manipulate that structure" (Carlisle, 1995, p. 194, see also Carlisle 2011) and *morphological processing* involves underlying cognitive processes involved in understanding and using morphological information (Bowers, Kirby, & Deacon, 2010; Deacon, Parrila, & Kirby, 2008). In their review of the literature on instruction in morphology, Bowers, Kirby, and Deacon (2010) use *morphological knowledge* instead of either the *awareness* or *processing* terms frequently used, due to the ambiguity of the learning processes that may or may not be used by students in relation to morphological instruction. aReading therefore typically refers to morphological knowledge and this background guided development of items to assess students' knowledge of the meaning behind parts of a word.

Vocabulary

The assessment of vocabulary in aReading focuses on assessing word knowledge and vocabulary outlined in the state and national standards and based on relevant reading research for K–12 readers including understanding and recognition of words in context that are appropriate for students at grade-level as well as appropriate for mature readers and writers to convey concepts, ideas, actions, and feelings (NAEP, 2011). These words include academic and content-specific words, word categories, word relations, and different parts of speech. The goal of vocabulary assessment should be to measure word knowledge in context rather than in isolation due to the integrated nature of reading comprehension in relation to vocabulary development.

Vocabulary is an oral language skill that involves understanding the semantic and contextual relations of a word(s) in both general and content-specific domains (Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). Vocabulary knowledge develops through general oral communication, direct instruction using contextual or decontextualized words and through reading connected texts in a variety of contexts (Nagy, 2005; Stahl & Kapunis, 2001). As new words are incorporated, word knowledge and efficiency of access is increased (Perfetti, 1994). Vocabulary is related to other reading skills (Cain, Oakhill, & Lemon, 2004; Ricketts, Nation, & Bishop, 2007), and a particularly strong interactive and reciprocal relation occurs between vocabulary and reading comprehension across ages (Carroll, 1993; McGregor, 2004; Muter, Hulme, Snowling, & Stevenson, 2004; Nation, Clarke, Marshall, & Durand, 2004; Nation & Snowling, 2004; Oakhill, et al., 2003).

Indeed, "Vocabulary knowledge is fundamental to reading comprehension; one cannot understand text without knowing what most of the words mean" (Nagy, 1988, p. 1). Developing a reading vocabulary typically enlists one's oral vocabulary: as a beginning reader comes across words that are less familiar in print, these are decoded and "mapped onto the oral vocabulary the learner brings to the task" (NRP, 2000, p. 4-3). If the word is not in the learner's oral vocabulary, decoding becomes less helpful and contextual information more important. Learning new words from text involves connecting the orthography to multiple contexts and establishing a flexible definition. Vocabulary knowledge, then, includes both definitional knowledge and contextual knowledge (Stahl, 1999). Some words in text are so familiar that they no longer require explicit processing; these are referred to as a sight word vocabulary (NRP).

Comprehension

The assessment of reading comprehension in aReading focuses on comprehension processes outlined in the state and national standards and based on relevant reading research for K–12 readers including the reader's development of an organized, coherent, and integrated representation of knowledge and ideas in the text through use of inferential processes and identification of key ideas and details in the text as well as understanding its craft and structure.

The goal of reading comprehension is to understand the meaning of what is heard and read. Comprehension is the process of understanding what is heard and read. Comprehension, or constructing meaning, is the purpose of reading and listening. The NRP noted that "Comprehension has come to be viewed as the 'essence of reading' (Durkin, 1993), essential not only to academic learning but to lifelong learning as well" (NRP, 2000, p. 4-11). "Good readers have a purpose for reading" (Armbruster, 2002, p. 34), like learning how to do something, finding out new information, or for the enjoyment and entertainment that reading for pleasure brings. Good readers actively process the test "to make sense of what they read, good readers engage in a complicated process. Using their experiences and knowledge of the world, their knowledge of vocabulary and language structure, and their knowledge of reading strategies . . ., good readers make sense of the text and know how to get the most out of it. They know when they have problems with understanding" and they know "how to resolve these problems as they occur" (Armbruster, 2002, p. 48). aReading items for grades 6–12 depended heavily on comprehension skills. Thus, the aReading team consulted with Dr. Paul van den Broek in spring 2012 to learn from his expertise in cognitive processes involved in reading comprehension. After meeting with Dr. van den Broek, the team ensured that questions about the reading passages should ask students to (a) locate and recall broad and specific information in the text, (b) integrate and interpret beyond the explicit information in the text, and (c) critique and evaluate the quality of the author's writing.

Uses and Applications

Each aReading assessment is individualized by the software and, as a result, the information and precision of measurement is optimized regardless of whether a student functions at, above, or significantly below grade level.

Target Population

aReading is intended for use from Kindergarten through Twelfth Grades for screening. The aReading item bank consists of approximately 2000 items that target the reading domains described in the previous section. Items developed for Kindergarten through Grade Five target Concepts of Print, Phonological Awareness, Phonics, Vocabulary, and Comprehension. Items developed for middle and high school grade levels target Orthography, Morphology, Vocabulary, and Comprehension. Please note, however, that the importance and emphasis on each reading domain will vary across children.

Chapter 2.2: Development

earlyReading

The results of the National Assessment of Educational Progress (NAEP) for 2011 suggest that among Fourth Grade students, 3% perform below a basic level (partial mastery of fundamental skills) and 68% perform below a proficient level of achievement (demonstrated competency over challenging subject matter) (National Center for Education Statistics, 2013). Among eighth grade students, 25% perform below basic and 68% perform below proficiency (Aud, Wilkinson-Flicker, Kristapovich, Rathbun, Wang, & Zhang, 2013). Approximately 32% of students demonstrate reading proficiency at grade level. The relatively low levels of reading proficiency and achievement within the general population are reflected within the population receiving services under the Individuals with Disabilities Education Act (IDEA), originally enacted in 1975. Among students who receive special education services, 91% of Fourth Graders and 95% of eighth graders fail to achieve grade-level proficiency in reading. Moreover, the majority of these students scored in the below basic range in reading achievement (National Center for Educational Statistics, 2003). The incidence of reading-related disabilities is disproportionately large when compared to other categories of disability under IDEA. Government data suggests that almost 60% of the students who are served under IDEA are identified with a specific learning disability, and 80% of those students are identified with a reading disability (U.S. Department of Education, 2001, 2002). Of the nearly 3 million students served under IDEA and the 1.5 million students identified with a specific learning disability, approximately 1.3 million are identified with a reading disability.

Reading instruction and reading development has never been better understood. Nevertheless, there is a great deal of progress to be made in the future by building on our present knowledge-base. The National Reading Panel identified five essential component skills that support reading development: phonemic awareness, phonics, fluency, vocabulary, and comprehension. They did not, however, define the relative scope and importance of each component within or across developmental phases. It is likely that specific skill-sets are most relevant and more salient at particular points in the developmental continuum (Paris, 2005). For elementary grades two through six, measures of fluency with connected text (curriculum based measure of oral reading; CBM-R) are often used as a universal screeners for grade-level reading proficiency. CBM-R requires students to read from a grade level passage for one minute while the number of words read correctly is recorded. Strong evidence exists in the literature to support the use of CBM-R (L.S. Fuchs, Fuchs, & Maxwell, 1988; Kranzler, Brownell, & Miller, 1998; Markell & Deno, 1997); however, support for CBM-R as a universal screener for students not yet reading connected text is less robust (Fuchs, Fuchs, & Compton, 2004; National Research Council, 1998). The research literature provides substantial guidance on instruction and assessment of alphabetic knowledge, phonemic awareness, and oral reading. The objective of earlyReading measures is to extend and improve on the quality of currently available assessments.

There is growing evidence that successful reading in elementary school grades depends on a combination of code-related and language comprehension skills. Code-related skills include the awareness that printed text is meaningful and the ability to translate the letters and words of the text into such meaningful concepts. Language comprehension skills concern the ability, knowledge and strategies necessary to interpret concepts and connect these concepts into a coherent mental representation of the text (Gough & Tunmer, 1986; Oakhill & Cain, 2007; Whitehurst & Lonigan, 1998).

A long tradition of research support indicates that early code-related skills predict later reading achievement (Adams, 1990; Chall, 1987; Juel, 1988; LaBerge & Samuels, 1974; National Reading Panel, 2000a; Stanovich, 1984). The design of earlyReading has a strong foundation in both research and theory. During the early phases of student reading development, the component processes of reading are most predictive of future reading success (Stanovich, 1981, 1984, 1990; Vellutino & Scanlon, 1987, 1991; Vellutino, Scanlon, Small, & Tanzman, 1991). Indeed, reading disabilities are most frequently associated with deficits in accurate and efficient word identification.

CBMreading

The National Reading Panel identified five essential component skills that support reading development: phonemic awareness, phonics, fluency, vocabulary and comprehension. Fluency (or rate) in particular, is important because it establishes a connection between word identification and comprehension. Despite research establishing CBM-R as a valid measure of general reading achievement, as well as an effective tool for predicting later reading performance, research also provides evidence for the necessity to improve CBM-R instrumentation and procedures. Estimates of longitudinal growth for individual students can be more a function of the instrumentation (i.e., inequitable passages) as opposed to students' actual response to intervention. Development of the CBMreading passages, therefore, was based on findings from existing research and theory. This provided clear guidance for ways to improve progress monitoring measures and outcomes that could yield substantial and significant improvements for a widely used approach to progress monitoring. These benefits are especially relevant within the evolving context of response to intervention, which relies substantially on CBM-R and rate-based measures of reading. The goal in creating the CBMreading measures, therefore, was to systematically develop, evaluate and finalize research-based instrumentation and procedures for accurate, reliable, and valid assessment and evaluation of reading rate.

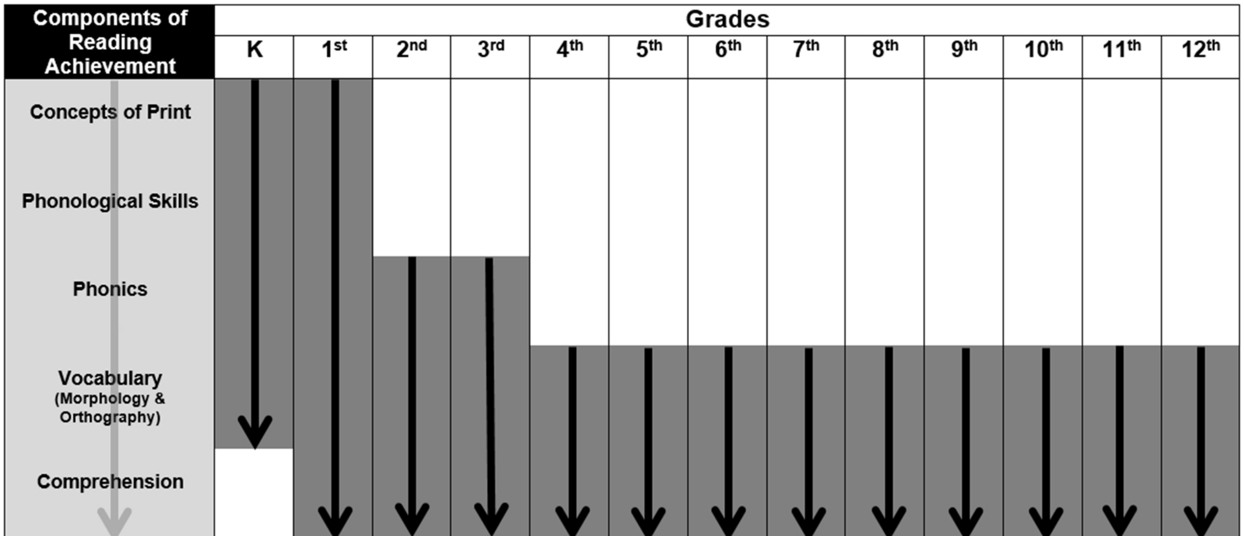
aReading

Similar to CBMreading, aReading item development followed the process and standards presented by Schmeiser and Welch (2006) in the fourth edition of Educational Measurement (Brennan, 2006). Research assistants, teachers from each grade level (1st through 12th), and content experts in the area of reading served as both item writers and reviewers for those items at the Kindergarten through 5th grade level. Items for grades 6 through 12 were constructed to reflect the Common Core State Standards' (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) specifications for various skills of interest, as well as the National Assessment of Educational Progress' (NAEP, 2011) guidelines for reading assessment items. After items were written at all grade levels, they were reviewed for feasibility, construct relevance, and content balance. A stratified procedure was used to recruit a diverse set of item writers from urban, suburban and rural areas. The item writers wrote, reviewed, and edited assessment materials.

Item writing for aReading was a multi-year, collaborative, and iterative process. First the literature on item writing guidelines used when developing assessments was reviewed. Next, the literature on multiple-choice item writing was reviewed. Once the literature was reviewed, the guidelines were applied to aReading to examine relevance and utility. Extensive guidelines and practice were provided to item writers and the process outlined above was followed.

The Item Development Process: An a-priori Model

aReading targets the essential skills that enable reading. In its current form aReading provides general estimate of overall reading achievement (i.e., a screening measure), which we define as the Unified Measure of Reading Achievement (see Figure 1 below). The research team established an a priori model of component skills and a unified measurement construct based on previous data and assumptions regarding typical rates of reading achievement. The use of grade levels is a convenience because the actual assessment is individualized to each student at the time of assessment (see later section regarding computer adaptive testing). The grade levels indicate only the likely relevant domains. These target skill components for assessment are derived from the research literature and are consistent with the recommendation of the National Reading Panel (2000) and critical components of most state standards for instruction and assessment.



Unified Measure of Reading Achievement	Unified K	Unified 1st	Unified 2nd	Unified 3rd	Unified 4th	Unified 5th	Unified 6th	Unified 7th	Unified 8th	Unified 9th	Unified 10th	Unified 11th	Unified 12th
aReading Norms	382-398	418-439	447-471	475-500	496-516	508-532	520-540	528-553	536-561	540-561	540-569	—	—
MAP RIT Scores	138-146	156-166	170-182	184-196	194-204	200-212	206-216	210-222	214-226	216-226	216-230	—	—
Lexile	BR	BR	BR-277	313-529	493-673	601-817	709-889	781-997	853-1069	889-1069	889-1141	—	—
Fountas & Pinnell	A-B	D-H	K-M	N-P	O-S	Q-Z	T-Z	X-Z	X-Z	Z	Z	—	—

Figure 1 A priori model for unified reading achievement

The Item Development Process: Alignment with Common Core State Standards

The Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science and Technical Subjects (furthered referred to as the Standards) is a synthesis of information gathered from state departments of education, assessment developers, parents, students, educators, and other pertinent sources to develop the next generation of state standards of K–12 students to ensure that all students are college and career literacy ready by the end of their high school education. This process is headed by the Council of Chief State School Officers (CCSO) and the National Governors Association (NGA). The Standards are an extension of a previous initiative by the CCSSO and NGA titled the College and Career Readiness (CCR) Anchor Standards. The CCR Anchor Standards are numbered from one to ten, and are as follows: (1) Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. (2) Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas. (3) Analyze how and why individuals, events, and ideas develop and interact over the course of a text. (4) Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone. (5) Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole. (6) Assess how point of view or purpose shapes the content and style of a text. (7) Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively as well as in words. (8) Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. (9) Analyze how two or more texts addresses similar themes or topics in order to build knowledge or to compare the approaches the authors take. (10) Read and comprehend complex literary and informational texts independently and proficiently. These anchor standards were designed with three themes in mind: craft and structure, integration of knowledge and ideas, and range of reading and level of text complexity.

The Standards add a level of specificity in the form of end of grade expectations for each of these ten anchor standards. To do this, the Standards organize the 10 anchor standards in three ways. First, a distinction is made between Literature and Information text. Secondly, the ten items are grouped into relevant clusters which are the same for both literature and information text. Those clusters are: Key Ideas and Details 1–3, Craft and Structure 4–6, Integration of Knowledge and Ideas 7–9, and Range of Reading and Level of Text Complexity 10. Further, the Standards provide a corresponding end of grade skill expectation by grade for each number within the cluster. A portion of the Readings Standards for Information Text is presented inRelevant to reading standards for students in Kindergarten through Fifth Grade, the CCSO and NGA identify foundational skills, including a working knowledge of concepts of print, the alphabetic principle, and other basic conventions of the writing system. Sub-categories under these foundational skills include print concepts, phonological awareness, phonics and word recognition, and fluency. It is important to acknowledge that at this point in time, fluency is not yet applicable to aReading. Print concepts encompass the ability to demonstrate the organization and basic feature of print. Phonological awareness is the ability to demonstrate an understanding of spoken words, syllables, and sounds or phonemes. Finally, phonics and word recognition includes applying grade-level phonics and word analysis skills in the process of decoding words. Within each category, there are specific end of the year expectations for each grade level. Examples are shown in

Table 2. Table 3 specifies cross-references between Common Core State Standards and aReading item domains.

Table 1 below. Similar, grade-level standards for all K–12 grade levels are available to view in the Common Core State Standards (2010).

Relevant to reading standards for students in Kindergarten through Fifth Grade, the CCSO and NGA identify foundational skills, including a working knowledge of concepts of print, the alphabetic principle, and other basic conventions of the writing system. Sub-categories under these foundational skills include print concepts, phonological awareness, phonics and word recognition, and fluency. It is important to acknowledge that at this point in time, fluency is not yet applicable to aReading. Print concepts encompass the ability to demonstrate the organization and basic feature of print. Phonological awareness is the ability to demonstrate an understanding of spoken words, syllables, and sounds or phonemes. Finally, phonics and word recognition includes applying grade-level phonics and word analysis skills in the process of decoding words. Within each category, there are specific end of the year expectations for each grade level. Examples are shown in

Table 2. Table 3 specifies cross-references between Common Core State Standards and aReading item domains.

Table 1. Example Standards for Informational Text

Reading Standards for Informational Text K–2		
Kindergarten	**Grade 1**	**Grade 2**
Key Ideas and Details		
1. With prompting and support, ask and answer questions about key details in a text.	1. Ask and answer questions about key details in a text.	1. Ask and answer such questions as who, what, where, when, why and how to demonstrate understanding of key details in a text.
2. With prompting and support, identify the main topic and retell key details of a text.	2. Identify the main topic and retell key details of a text.	2. Identify the main topic of a multi-paragraph text as well as the focus of specific paragraphs within the text.
3. With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text.	3. Describe the connection between two individuals, events, ideas, or pieces of information in a text.	Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.

Table 2. Foundational Skill Examples for Kindergarten and First Grade Students

Reading Standards: Foundational Skills (K–1)	
Kindergarten	Grade 1
Print Concepts	
1. Demonstrate understanding of the organization and basic features of print.	1. Demonstrate understanding of the organization and basic features of print.
a. Follow words from left to right, top to bottom, and page by page.	a. Recognize the distinguishing features of a sentence (e.g., first word, capitalization, ending punctuation).
b. Recognize that spoken words are represented in written language by specific sequences of letters.	
c. understand that words are separated by spaces in print.	
d. Recognize and name all upper- and lowercase letters of the alphabet.	

Table 3. Cross-Referencing CCSS Domains and aReading Domains

Common Core Subgroups / Clusters	aReading Domains

Foundational Skills	
Print Concepts	Concepts of Print
Phonological Awareness	Phonemic Awareness
Phonetic Awareness	Phonetic Awareness
Vocabulary	Vocabulary
College and Career Readiness Reading Standards for Literature / Informational Text	
Key Ideas and Details	Comprehension
Craft and structure	Comprehension & Vocabulary
Integration of Knowledge and Ideas	Comprehension & Vocabulary

Chapter 2.3: Administration and Scoring

earlyReading

Administration time varies depending on which earlyReading assessment subtest is being administered. A timer is built into the software and is required for all subtests. For those assessments that calculate a rate-based score (i.e., number correct per minute), the default test duration is set to one minute. These subtests include Letter Names, Letter Sounds, Sight Words, Decodable Words, and Nonsense Words. For those subtests that do not calculate a rate-based score (number correct), the default test duration is set to open-ended. This includes Concepts of Print, Onset Sounds, Word Rhyming, Word Segmenting, and Word Blending subtests. Although it is not recommended, those administering the assessments can change the test duration by selecting options from a drop-down menu. earlyReading is individually administered, and each subtest can take approximately one to three minutes to complete; administration of the composite assessments for universal screening takes approximately 5 minutes.

CBMreading

CBMreading includes standardized administration and scoring procedures along with proprietary instrumentation, which was developed with funding from the US Department of Education and Institute for Education Sciences. CBMreading takes approximately one minute to administer a single passage. The administration of three passages takes approximately five minutes per student.

If a student stops or does not say a word aloud for three seconds, tell the student the word, mark the word as incorrect, and instruct the student to continue. Aside from the three second rule, do not provide the student with correct responses, or correct errors that the student makes. Alternate scoring methods include word-by-word error analysis and performance analysis to evaluate the types of errors committed by students.

aReading

aReading can be group administered in a computer lab setting, or a student can complete an administration individually at a computer terminal set up in a classroom. The aReading assessment terminates on its own, informing students they have completed all items. A typical aReading administration is approximately 30 items. Students in grades K–5 take an average of 10–15 minutes to complete an assessment, and students in grades 6–12 take an average of 20–30 minutes. Administration time may vary by student. Instructions for completing aReading are provided via headphones to students. In addition to audible instructions, students are provided with an animated example. No verbal instructions are required on behalf of the administrator.

Chapter 2.4: Interpreting Test Results

earlyReading

Raw Scores

Each earlyReading subtest produces a raw score. The primary score for each subtest is the number of items correct and/or the number of items correct per minute. These raw scores are used to generate percentile ranks.

Composite Scores

The best estimate of students' early literacy skills is the earlyReading composite score. The composite score consists of multiple subtest scores administered during a universal screening period. The earlyReading composite scores were developed as optimal predictors of spring broad reading achievement in Kindergarten and First Grade. A selected set of individual subtest scores were weighted to optimize the predictive relationship between earlyReading and broad reading achievement scores (See Table 4 below). The weighting is specific to each season. It is important to emphasize that the weighting is influenced by the possible score range and the value of the skill. For example, letter sounds is an important skill with a score range of 0 to 60 or more sounds per minute. This represents a broad range of possible scores with benchmark scores that are fairly high (e.g., benchmarks for fall, winter, and spring might be 10, 28, and 42, respectively). In contrast, Concepts of Print has a score range from 0 to 12 and benchmarks are relatively low in value (e.g., benchmarks for fall and winter might be 8 and 11, respectively). As a result of both the score range *and* the relative value of Concepts of Print to overall early reading performance, the subtest score is more heavily weighted in the composite score. The weightings are depicted in Table 4 (below). The high (H), moderate (M), and low (L) weights indicate the relative influence of a one point change in the subtest on the composite score. A one point change for an H weighting is highly influential. A one point change in an L weighting has low influence.

The composite scores should be interpreted in conjunction with specific subtest scores. A variety of patterns might be observed. It is most common for students to perform consistently above or below benchmark on the composite and subtests; however, it is also possible to observe that a particular student is above benchmark on one or more measures but below the composite benchmark. It is also possible for a student to be below benchmark on one or more subtests but above the composite benchmark. Although atypical, this phenomenon is not problematic. The recommendation is to combine the use of composite and subtest scores in order to optimize the decision-making process. Overall, composite scores are the best predictors of future reading success.

Table 4. Weighting Scheme for earlyReading Composite Scores

	Kindergarten			First Grade		
earlyReading Subtests	**F**	**W**	**S**	**F**	**W**	**S**
Concepts of Print	H					
Onset Sounds	M	H				
Letter Names	L					
Letter Sounds	L	L	L			
Word Segmenting		L	M	L	L	L
Nonsense/Decodable Words		M	M	H	H	H
Sight Words			L	M	M	M
Sentence Reading				L		
CBMreading					L	L
Broad Score						

Note. The weighting of subtests for the composite is represented above.
H – high weighting, M – moderate weighting, L – low weighting.

Kindergarten

The composite score for Kindergarten students in the fall includes Concepts of Print, Onset Sounds, Letter Sounds, and Letter Naming. The composite score for winter includes Onset Sounds, Letter Sounds, Word Segmenting and Nonsense Words. Finally, for spring of the Kindergarten year, the following subtests are recommended in order to compute an interpretable composite score: Letter Sounds, Word Segmenting, Nonsense Words, and Sight Words (50). The Decodable Words score may be used in place of Nonsense Words for computing any of the composite scores specified.

First Grade

The composite score for First Grade students in the fall includes Word Segmenting, Nonsense Words, Sight Words (150), and Sentence Reading. The composite score for winter includes Word Segmenting, Nonsense Words, Sight Words (150), and CBMreading. Finally, for spring of First Grade, the following subtests are recommended in order to compute an interpretable composite score: Word Segmenting, Nonsense Words, Sight Words (150), and CBMreading. The Decodable Words score may be used in place of Nonsense Words for computing any of the composite scores specified.

Benchmark Scores

Benchmark scores are available for each earlyReading subtest for the specific grade level and month for which they are intended for use. Thus, a benchmark is purposefully not provided for every subtest, for each month, during Kindergarten and First Grade. Benchmarks were established for earlyReading to help teachers accurately identify students who are at risk or not at risk for academic failure. These benchmarks were developed from a criterion study examining earlyReading assessment scores in relation to scores on the Group Reading Assessment and Diagnostic Evaluation (GRADE; Williams, 2001). Measures of diagnostic accuracy were used to determine decision thresholds using criteria related to sensitivity, specificity, and area under the curve (AUC). Specificity and sensitivity was computed at different cut scores in relation to maximum AUC values. Decisions for final benchmark percentiles were generated based on maximizing each criterion at each cut score (i.e., when the cut score maximized specificity ≥ .70, and sensitivity was also ≥ .70; see Silberglitt & Hintze, 2005). Based on these analyses, the values at the 40th and 15th percentiles were identified as the primary and secondary benchmarks for earlyReading, respectively. These values thus correspond with a prediction of performance at the 40th and 15th percentiles on the GRADE™ (Group Reading Assessment and Diagnostic Evaluation), a nationally normed reading assessment of early reading skills. Performance above the primary benchmark indicates the student is at low risk for long-term reading difficulties. Performance between the primary and secondary benchmarks indicates the student is at some risk for long-term reading difficulties. Performance below the secondary benchmark indicates the student is at high risk for long-term reading difficulties. These risk levels help teachers accurately monitor student progress using the FAST™ earlyReading measures. Benchmarks are reported in the FastBridge Learning: Benchmarks and Norms Guide.

CBMreading

Interpreting CBMreading scores involves a basic understanding of the various scores provided in the FAST™ software.

Total Words Read

Total Words Read refers to the total number of words read by the student, including correct and incorrect responses.

Number of Errors

This is the total number of errors the student made during the one minute administration time.

Words Read Correct per Minute (WRC/min)

This is the number of Words Read Correct per minute. This is computed by taking the total number of words read and subtracting the number of errors the student made.

Benchmark Scores

Benchmark scores are available for CBMreading by grade level and time of the year (i.e., fall, winter, spring) for which they are intended for use. A benchmark is provided for every grade level (1-6), for each of the three time points throughout the school year. The assessment of oral reading rate with

CBM-R is well established in the literature for use to benchmark student progress (Wayman et al., 2007). Benchmarks were established for CBMreading to help teachers accurately identify students who are at risk or not at risk for reading difficulties. All CBMreading forms are divided into Levels A, B and C, which correspond to 1st grade (A), 2nd and 3rd grade (B), and 4th through 6th grade (C) reading levels, respectively. There are 39 Level A passages, 60 Level B, and 60 Level C passages. Each passage is assigned as a screening/benchmarking form for each grade level (1st to 6th) and a variety of progress monitoring forms. The weekly passage set options include: one unique passage weekly (1x weekly), two unique passages weekly (2x weekly), or three unique passages weekly (3x weekly). Analyses were conducted to link CBMreading scores with DIBELS Next and AIMSweb benchmark and target scores.

Measures of diagnostic accuracy were used to determine decision thresholds using criteria related to sensitivity, specificity, and area under the curve (AUC). Specifically, specificity and sensitivity was computed at different cut scores in relation to maximum AUC values. Decisions for final benchmark percentiles were generated based on maximizing each criterion at each cut score (i.e., when the cut score maximized specificity ≥ .70, and sensitivity was also ≥ .70; see Silberglitt & Hintze, 2005). Benchmarks generally correspond to the 40th and 15th percentiles on nationally normed assessments and FAST™ norms. Benchmarks are reported in the FastBridge Learning: Benchmark and Norms Guide.

aReading

Interpreting aReading scores involves a basic understanding of the various scores provided in the FAST™ software.

Scaled Scores

Scores generated by the aReading computer-adaptive test (CAT) yield scores based on an IRT logit scale. This type of scale is not useful to most school professionals; in addition, it is difficult to interpret scores on a scale for which everything below the mean value yields a negative number. Therefore, it was necessary to create an aReading scale more similar to existing educational measures. Such scales are arbitrarily created with predetermined basal and ceiling scores. For instance, the Measure of Academic Progress (MAP; NWEA) uses a scale from 150 to 300 and STAR Early Literacy (Renaissance Learning) uses a scale from 300 to 850.

The aReading scale yields scores that are transformed from logits using the following formula:

$$y = 500 + (50 \times \text{Logit Score})$$

The logit scale has an $M = 0$ and $SD = 1$ and y is the new aReading scaled score, and θ (theta) is the initial aReading logit theta estimate. Scores were scaled with a lower bound of 350 and a higher bound of 650. The mean value is 500 and the standard deviation is 50. There are several shortcomings in reporting logit scores to educational professionals. Among these are: (a) teachers are unfamiliar with a measure ranging in six points with decimals and (b) using the current logit reporting scheme, negative values demarcate ability estimates below average. Displaying negative values for ability estimates may carry with it off-putting connotations. Thus, the researchers for aReading chose to adopt an arbitrary scale upon which to report logit scores and theta estimates. The idea of reporting scores on the same scale as standard intelligence tests was considered but ultimately dismissed. The reason for dismissing this idea was two-fold; the researchers wanted to avoid educators and parents inaccurately equating aReading scores with IQ scores. In addition, creating a novel and arbitrary scale would encourage educators to refer to the current technical manual for assistance in interpreting such scores accurately. Details on interpreting aReading scaled scores for instructional purposes is delineated in the following section.

Interpreting Scaled Scores

aReading scaled scores have an average of 500 and standard deviation of 50 across the range of Kindergarten to twelfth grades. Scores should be interpreted with reference to the benchmarks and norms. In addition, aReading has descriptions regarding the interpretation of a student's scaled score with respect to mastered, developing, and future skill development. These are intended to help teachers better understand the developmental progression and student needs. FAST™ generates individual reports to describe the reading skills that the student has mastered, is developing, and will develop based on their scaled score Figure 2 shows an example of a student's score report and her mastered, developing, and future skills for Concepts of Print.

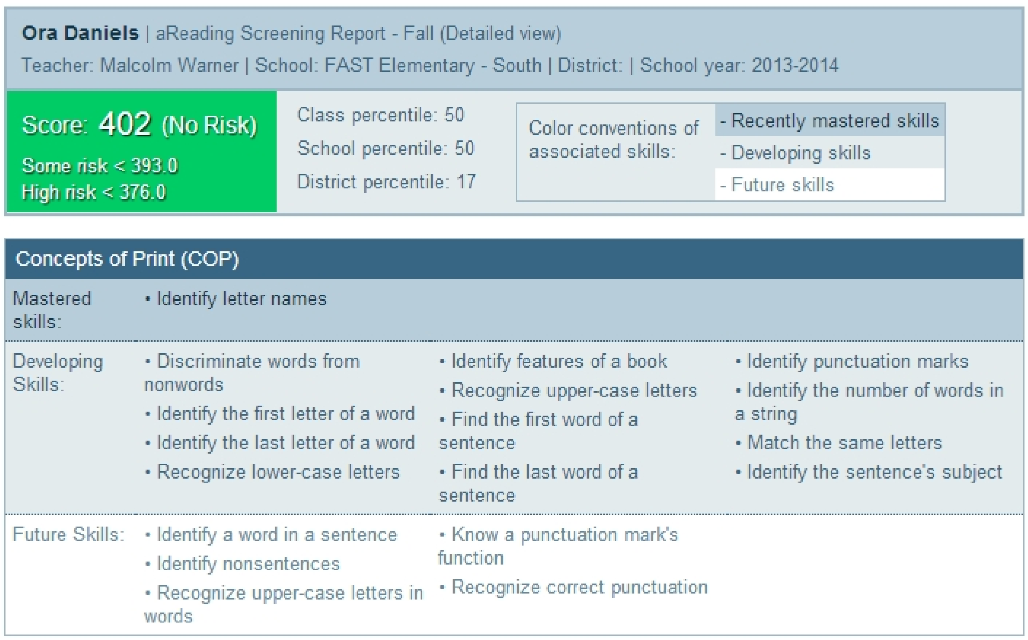


Figure 2. Example of a student's aReading report with interpretations of the scaled score

Benchmark Scores

Benchmark scores for aReading are available for Kindergarten through Twelfth Grade at three time periods: fall, winter, and spring. Benchmarks were established for aReading to help teachers accurately identify students who are at risk or not at risk for academic failure. Benchmarks are reported in the FastBridge Learning: Benchmark and Norms Guide.

Chapter 2.5: Reliability

earlyReading

earlyReading measures were administered to Kindergarten and First Grade students from nine elementary schools across three school districts in a metropolitan area in the Midwest. Kindergarten students who participated in the study were enrolled in all-day Kindergarten programming. The demographic information for each school district is provided in Table 5.

Table 5. Demographic Information for earlyReading Alternate Form Sample

Category	District A	District B	District C
White	56.1%	93%	79.5%
Black	13.5%	4%	6.8%
Hispanic	10.3%	3%	4.5%
Asian/Pacific Islander	19.4%	4%	10.5%
American Indian/Alaska Native	>.1%	1%	.25%
Free/Reduced Lunch	44.9%	17%	9%
LEP	15.8%	6%	6%
Special Education	12.6%	10%	10%

Classrooms were recruited by the reading coordinator within each school district. Teachers received a $20.00 gift card for participating. Five progress monitoring alternate forms were randomly chosen for each earlyReading measure (for which progress monitoring forms exist). Students were administered five forms of one to two earlyReading measures consecutively in one sitting. Administration was conducted by trained administrators who all attended a two-hour training session in addition to completing integrity checks while working with students.

Evidence of reliability is available for Alternate Forms for all earlyReading subtests (see

Table 6). In order to effectively examine reliability coefficients, Standard error of measurement (SE*m*) has also been provided. The SE*m* is an index of measurement error representing the standard deviation of errors attributable to sampling. The SE*m* provides information about the confidence with which a particular score can be interpreted, relative to a single individual's true score. Thus, a small SE*m* represents greater confidence that a score reflects the individual's true performance and skill level. The SE*m* is based on the formula $SEm = SD\sqrt{1-r}$ where SD represents the standard deviation of the distribution and r represents the reliability of the measure. The SE*m* can be used by those administering the measure to help interpret the score obtained by a student. The SE*m* for both Kindergarten and First Grade are available for each subtest in

Table 6. To determine parallel form construction, ANOVAs were conducted to compare alternate forms for each individual subtest. See below for a complete description of parallel form construction for the

following earlyReading subtests: Onset Sounds, Letter Naming, Letter Sounds, Word Blending, Word Segmenting, Decodable Words, and Nonsense Words.

Table 6. Alternate Form Reliability and SE*m* for earlyReading

Grade	N (range)	Coefficient		SE*m* (SD)
		Range	Median	
Kindergarten				
Onset Sounds	25–29	.77–.89	.83	.99 (.86)
Letter Naming	36–37	.82–.92	.88	5.07 (3.77)
Letter Sound	34–36	.85–.94	.89	5.56 (4.89)
Word Blending	36–37	.59–.79	.71	.97 (.82)
Word Segmenting	37–38	.68–.92	.82	8.07 (6.21)
Decodable Words	29	.96–.98	.97	2.93 (2.71)
Nonsense Words	28	.86–.96	.93	2.15 (1.91)
Sight Words (50)	24–28	.94–.99	.97	4.40 (4.13)
Nonsense Words	28	.86–.96	.93	2.15 (1.91)
Grade 1				
Word Blending	30–31	.15–.59	.26	
Word Segmenting	40	.67–.87	.82	9.83
Decodable Words	36–37	.97–.98	.98	2.98
Nonsense Words	26–27	.69–.96	.85	3.05 (3.04)
Sight Words (150)	37	.91–.96	.94	4.14

Note. SD = Standard Deviation.

Alternate Form Reliability

Onset Sounds. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Onset Sounds alternate forms ($n = 5$) on the number of correct responses within individuals. There was not a significant effect for forms $F(1,109) = 1.81$, $p = .18$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Letter Names. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Letter Names alternate forms ($n = 5$) on the number of correct responses within individuals. There was not a significant effect for forms $F(1,146) = .71$, $p = .40$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Letter Sounds. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Letter Sounds alternate forms ($n = 5$) on the number of correct responses within individuals. There was not a significant effect for forms $F(1,139) = .96$, $p = .33$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Word Blending. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Word Blending alternate forms ($n = 5$) on the number of correct responses within individuals. There was not a significant effect for forms $F(1,121) = 1.60$, $p = .21$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Word Segmenting. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Word Segmenting alternate forms (n=5) on the number of correct responses within individuals in both Kindergarten and grade 1. There was not a significant effect for forms as used in either grade: Kindergarten = $F(1,150) = 3.24$, $p = .07$; grade 1 = $F(1,121) = 1.60$, $p = .21$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Decodable Words. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Decodable Words alternate forms ($n = 5$) on the number of correct responses within individuals. There was not a significant effect for forms $F(1,145) = 1.72$, $p = .19$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Nonsense Words. To determine parallel form construction, a one-way, within-subjects (or repeated measures) ANOVA was conducted to compare the effect of Nonsense Words alternate forms ($n = 5$) on the number of correct responses within individuals. For Kindergarten, there was not a significant effect for forms $F(1,107) = .03$, $p = .86$. For First Grade, there was not a significant effect for forms $F(1,106) = 2.34$, $p = .13$. This indicates that different forms did not result in significantly different mean estimates of correct responses.

Internal Consistency (Item-Total Correlations)

Some earlyReading measures have fixed test lengths and are subject to typical internal consistency analyses. Some earlyReading measures, however, are timed. Different students will therefore have tests of different lengths. Internal consistency measures of reliability are inflated on timed measures because of the high percentage of incomplete items at the end of the assessment, which are those for which examinees did not respond (Crocker & Algina, 1986). As a solution to both illustrate the potential inflation and also reduce it, estimates of internal consistency (reliability) were run on the items completed by approximately 16% of students, the items completed by 50% of students, and items completed by approximately 84% of students. Items not completed were coded as incorrect. For both fixed test -length and inconsistent test-length analyses, data were derived from a random sample of students from the FAST™ database from the 2012–13 academic year. Reliability of measures with variable test length is reported in .

Table 7. Reliability of measures with fixed test length is reported in Table 8.

Table 7. Internal Consistency for earlyReading Subtests of Variable Test Length

Measure	Grade	N	Alpha	Split-Half
Letter Names	K	444		
18 items			.95	.96
35 items			.98	.99
52 items			.98	.99
Letter Sounds	K	683		
10 items			.93	.93
30 items			.98	.98
50 items			.98	.99
Decodable Words	K-1	434		
6 items			.76	.75
23 items			.95	.96
40 items			.98	.98
Nonsense Words	K–1	501		
5 items			.74	.73
18 items			.93	.95
31 items			.96	.98
Sight Words (50)	K–1	505		
11 items			.90	.91
29 items			.97	.98
47 items			.99	.99
Sight Words (150)	1	678		
12 items			.90	.91
53 items			.99	.99
94 items			.99	.99

Table 8. Internal Consistency for earlyReading Subtests of Fixed Test Length

Measure	Grade	N	# of items	Alpha	Split-Half
Concepts of Print	K	336	12	.75	.76
Onset Sounds	K	597	16	.87	.91
Rhyming	K	586	16	.94	.91

Word Blending	K–1	480	10	.90	.91
Word Segmenting	K–1	500	10	.95	.96

Test-Retest Reliability

In fall 2012, data were collected to determine test-retest reliability for all earlyReading screening measures. Participants included 85 Kindergarten and 71 First Grade students from two elementary schools in a metropolitan area in the Midwest. Kindergarten students who participated in the study were enrolled in all-day Kindergarten at two elementary schools within the same school district.

Table 9. Descriptive Information for earlyReading Test-Retest Reliability Sample

Grade	Measure	N	Min	Max	SD	Mean	Max Possible
Time 1 (*Note. Time 1 is based on fall screening data)*							
K	Concepts of Print	39	3	12	1.96	9.46	12
K	Onset Sounds	39	2	16	2.94	13.74	16
K	Letter Naming	39	2	52	15.91	32.23	52/min
K	Letter Sound	39	0	50	13.36	19.62	38/min
K	Rhyming	39	0	16	4.60	11.77	16
K	Word Blending	39	0	10	3.81	3.92	10
Time 2 (~3 weeks later)							
K	Concepts of Print	40	5	12	2.07	9.7	12
K	Onset Sounds	40	5	16	2.35	14.15	16
K	Letter Naming	40	2	52	15.73	31.70	52/min
K	Letter Sound	40	1	39	11.23	19.43	38/min
K	Rhyming	40	4	16	3.74	12.18	16
K	Word Blending	34	0	9	3.13	3.71	10
Time 1 *(Note. Time 1 is based on fall screening data)*							
1st	Word Blending	37	0	10	7.19	2.94	10
1st	Word Segmenting	37	4	34	55.81	7.50	32
1st	Decodable Words	37	0	49	12.82	14.10	50/min
1st	Nonsense Words	37	1	34	10.65	8.39	50/min
1st	Sight Words (150)	37	1	91	35.35	24.21	150/min
1st	Sentence Reading	37	1	181	42.68	38.60	
1st	Composite	33	79	128	11.99	104.5	
Time 2 (~3 weeks later)							
1st	Word Blending	37	0	10	11.00	14.75	10
1st	Word Segmenting	37	14	34	27.57	5.28	32
1st	Decodable Words	37	0	50	17.22	13.95	50/min
1st	Nonsense Words	37	0	50	17.97	12.53	50/min
1st	Sight Words (150)	37	0	109	46.41	29.48	150/min
1st	Sentence Reading	37	0	220	55.81	50.13	
1st	Composite	33	80	138	13.58	110.03	

All First Grade students who participated in the study were from a single school. The majority of students within the school district were White (78%), with the remaining students identified as either Black (19%), or other (3%). Forty to fifty percent of students at each school were on free and reduced lunch. For details regarding the demographic sample for this data collection, see Table 9. Coefficients in Table 10 with larger sample sizes (i.e., larger than the above specified sample) were derived from a convenience sample from the FAST™ database. This sample was approximately 85% White.

Teachers randomly selected three to five students and sent home passive consent forms. The first administration of earlyReading measures were given by classroom teachers during a two-week screening period. All teachers attended a two-hour training session on earlyReading measures and were observed by the lead teacher at each school for a percentage of the time to confirm administration integrity. The second administration of the earlyReading measures were given by a team of school psychology graduate students. All graduate students also attended a two-hour training session related to earlyReading administration. This second administration took place two to three weeks after the termination of the initial screening period. Due to ongoing data collections, test-retest reliability evidence has been provided for additional time intervals: fall (F) to winter (W), winter to spring (S), and fall (F) to spring (S). Sample sizes vary by time interval. Test-retest reliabilitis are reported in Table 10.

Table 10. Test-Retest Reliability for all earlyReading Screening Measures

		Test-Retest Coefficient (N)			
Measure	Grade	2-3 Weeks	F to W	W to S	F to S
Concepts of Print	K	.42 (39)	.66 (89)	.58 (90)	.51 (168)
Onset Sounds	K	.79 (67)	.75 (89)	.67 (90)	.58 (167)
Letter Names	K	.94* (45)	.65 (1781)	.55 (951)	.45 (1141)
Letter Sounds	K	.92 (75)	.51 (1241)	.61 (1282)	.35 (1600)
Rhyming	K	.74 (39)	.68 (917)	.62 (946)	.46 (1130)
Word Blending	K	.73 (70)	.59 (832)	.59 (856)	.34 (1069)
Word Segmenting	K	.86 (37)	--	.61 (834)	--
Decodable Words	K	.98 (29)	.70 (56)	.68 (168)	--
Nonsense Words	K	.94 (27)	.70 (119)	.74 (321)	--
Sight Words (50)	K	.97 (34)	--	.73 (169)	--
Composite	K	--	.91 (191)	.68 (185)	.71 (220)
Word Blending	1	.77 (67)	.61 (592)	.78 (579)	.54 (568)
Word Segmenting	1	.83 (77)	.52 (589)	.70 (582)	.48 (573)
Decodable Words	1	.97 (73)	.80 (2152)	.84 (604)	.69 (1194)
Nonsense Words	1	.76 (64)	.78 (1977)	.82 (439)	.65 (1046)
Sight Words (150)	1	.94 (74)	.84 (913)	.82 (432)	.60 (1137)
Sentence Reading	1	.98 (37)	Pending	Pending	Pending
Composite	1	.97 (33)	.90 (153)	.92 (104)	.88 (118)

Note. Sample size provided in parentheses. F = Fall. S = Spring. W = Winter.
*Outliers that were +/- 2 standard deviations from the mean were removed from the test-retest reliability sample. In this case 2 cases, making up 3% of the sample, were removed.

Table 11. Disaggregated Test Re-Test Reliability for earlyReading Measures

			Test-Retest Coefficient (N)			
Measure	Ethnicity	Grade	2-3 Weeks	F to W	W to S	F to S
Letter Names	Black	K	--	.69 (293)	--	.57 (274)
Letter Names	Hispanic	K	--	.61 (194)	--	.44 (179)
Letter Names	White	K	--	.61 (1129)	--	.40 (1293)
Letter Sounds	Black	K	--	.53 (409)	--	.45 (408)
Letter Sounds	Hispanic	K	--	.46 (270)	--	.29 (292)
Letter Sounds	White	K	--	.50 (1410)	--	.31 (1687)
Nonsense Words	Black	K	--	.52 (23)	--	.28 (38)
Nonsense Words	Hispanic	K	--	.73 (91)	--	.54 (102)
Onset Sounds	Black	K	--	.53 (424)	--	--
Onset Sounds	Hispanic	K	--	.51 (274)	--	--
Onset Sounds	White	K	--	.49 (1418)	--	--
Word Segmenting	Black	K	--	.61 (49)	--	.32 (52)
Word Segmenting	Hispanic	K	--	.54 (15)	--	.28 (20)
Word Segmenting	White	K	--	.61 (163)	--	.24 (230)
Word Blending	Black	K	--	.56 (219)	--	.34 (222)
Word Blending	Hispanic	K	--	.48 (129)	--	.30 (134)
Word Blending	White	K	--	.56 (533)	--	.33 (778)
Nonsense Words	Black	1	--	.74 (337)	--	.60 (179)
Nonsense Words	Hispanic	1	--	.74 (225)	--	.66 (121)
Nonsense Words	White	1	--	.78 (1156)	--	.63 (624)
Decodable Words	Black	1	--	.80 (375)	--	.73 (206)
Decodable Words	Hispanic	1	--	.75 (260)	--	.63 (138)
Decodable Words	White	1	--	.79 (1220)	--	.67 (707)
Sight Words (150)	Black	1	--	.84 (172)	--	.62 (194)
Sight Words (150)	Hispanic	1	--	.73 (123)	--	.52 (133)
Sight Words (150)	White	1	--	.87 (501)	--	.59 (674)
Word Segmenting	Black	1	--	.60 (171)	--	.53 (205)
Word Segmenting	Hispanic	1	--	.57 (128)	--	.52 (142)
Word Segmenting	White	1	--	.48 (447)	--	.46 (692)
Word Blending	Black	1	--	.66 (172)	--	.51 (205)
Word Blending	Hispanic	1	--	.58 (130)	--	.50 (142)
Word Blending	White	1	--	.48 (452)	--	.36 (705)

Inter-Rater Reliability

earlyReading measures involve a small degree of subjectivity, given clear scoring guidelines and software-assisted scoring mechanisms. Unreliable scoring in regards to earlyReading may be the result of clerical errors or differences in the interpretation of a student's response. To alleviate such error, examples and detailed responses are provided in the earlyReading Screening Administration Technical Manual.

Evidence of inter-rater reliability is provided in Table 12. All coefficients represent Pearson product-moment correlation coefficients (Pearson *r*). For demographic information on the sample from which inter-rater reliability coefficients were derived, see Table 5.

Table 12. Inter-Rater Reliability by earlyReading Subtest

Subtest	Grade	Correlation Coefficient	N
Onset Sounds	K	.98	40
Letter Sounds	K	.99	47
Letter Names	K	.99	69
Word Blending	K	.98	95
Word Segmenting	K	.85	90
Sight Words (50)	K	.99	9
Word Blending	1	.89	159
Word Segmenting	1	.83	85
Decodable Words	1	.99	120
Sight Words (150)	1	.97	125
Nonsense Words	1	.99	51

Reliability of the Slope

Data collected during a normative information-aimed study was used to determine reliability of the slope for earlyReading measures. Participants included Kindergarten and First Grade students from various elementary schools. Students were administered one or more earlyReading measures at three time points throughout the school year (see below)

Table 13. Demographic Information for earlyReading Reliability of the Slope Sample

Category	Kindergarten (N)	1st Grade (N)
Female	2086	1604
Male	2196	1555
White	2710	2114
Black	688	429
Hispanic	439	288
Asian/Pacific Islander	322	252
Other	123	77
General Education	2656	1727
Special Education	1345	1296
Unspecified	1626	1433

Reliability of the slope was calculated for earlyReading screening and progress monitoring data. This data is shown in Table 14. Reliability of the slope data has also been disaggregated by ethnicity. Disaggregated information is also provided (See Table 15).

Table 14. Reliability of the Slope for All earlyReading Screening Measures

Subtest	Grade	N	Coefficient
Onset Sounds	K	2129	.91
Letter Names	K	1627	.81
Letter Sounds	K	2229	.88
Rhyming	K	904	.38
Word Blending	K	958	.73
Word Blending	1	824	.77
Word Segmenting	K	235	.60
Word Segmenting	1	824	.78
Decodable Words	K	52	.59
Decodable Words	1	918	.86
Sight Words (50)	K	167	.22
Sight Words (150)	1	624	.77
Nonsense Words	K	116	.75
Nonsense Words	1	664	.87

Note. All of the above information is based on three time points: fall, winter, and spring data.

Table 15. Reliability of the Slope for earlyReading measures, Disaggregated by Ethnicity

Subtest	Grade	N	Coefficient	Ethnicity
Onset Sounds	K	342	.90	Black
		253	.89	Hispanic
		1253	.92	White
Letter Sounds	K	366	.93	Black
		247	.86	Hispanic
		1332	.89	White
Letter Names	K	256	.80	Black
		177	.76	Hispanic
		1049	.83	White
Nonsense Words	K	22	.70	Black
		89	.81	White
Word Blending	K	206	.77	Black
		125	.57	Hispanic
		515	.74	White
Word Blending	1	156	.93	Black
		123	.74	Hispanic
		420	.77	White
Word Segmenting	K	156	.78	Black
		122	.77	Hispanic
		418	.73	White
Word Segmenting	1	48	.60	Black
		15	.36	Hispanic
		157	.65	White
Nonsense Words	1	153	.93	Black
		92	.89	Hispanic
		328	.85	White
Decodable Words	1	199	.88	Black
		136	.91	Hispanic
		449	.83	White
Sight Words (150)	1	130	.71	Black
		103	.85	Hispanic
		303	.79	White

Note. All of the above information is based on three time points: fall, winter, and spring data.

CBMreading

The CBMreading passages in FAST™ have been systematically developed and field tested over a number of years to address the problems with pre-existing passage sets that introduced error into measurement of student reading rate during screening and progress monitoring. The goal in creating the CBMreading measures was to systematically develop, evaluate, and finalize research-based instrumentation and procedures for reliable assessment and evaluation of reading rate. Christ and Ardoin (2009) described their initial method for FAIP-R field testing and passage-set development, which was designed to minimize variance due to instrumentation/passages and optimize progress monitoring reliability/precision. In a follow-up study, Ardoin and Christ (2009) directly compared FAIP-R passages to DIBELS and AIMSweb passage sets in a peer-refereed publication. In the only published study of its kind, they concluded that FAIP-R passages yielded less error and more precise estimates than either AIMSweb or DIBELS—with the most substantial improvements over the DIBELS system. Progress monitoring requires a set of equivalent reading passages, a schedule, graphing procedures, and trend line or data-point decision rules due to the increased frequency of CBM-R administration. The materials and decision rules guiding material use, selection, and schedule of administration in CBMreading have all been developed with these core elements in mind.

The CBMreading passages in FAST™ were initially developed and field tested with 500 students per level. All passages were designed with detailed specifications and in consultation with educators and content experts. The researchers analyzed data from three rounds of field testing and edited passages to optimize the semantic, syntactic, and cultural elements. Evidence of test-retest reliability and reliability of the slope was derived from the same sample of participants.

Alternate Form Reliability

First Passage Reduction

Alternate forms of FAIP-R oral reading passages were administered in order to identify the best set of passages to use when measuring oral reading rate with students at differing levels of ability in first through Fifth Grades. Three passage sets of different difficulty level were constructed.

Student participants were from urban and suburban schools located in the Southeast, the upper Midwest, and Northeastern regions of the US. A passive-consent procedure was used so that students whose parents opted out of participation were excluded from the sample. The sample consisted of 177 participants from Kindergarten through Fifth Grades. Fifteen students were sampled from Kindergarten and First Grades in the upper Midwest site. Across all three sites, 40 students were selected from second and Third Grade classrooms (n=80) and 40 students were selected from fourth and Fifth Grade classrooms (n=80; two extra participants were seen at the Northeastern site). Information about participant characteristics in the overall and disaggregated sample is provided in Table 16.

Table 16. Demographic Information for CBMreading First Passage Reduction Sample

Grade	Sex		Age	Race					SES[a]	Special Education
	F	M		A	B	H	Am	W		
Overall										
K	3	2	6 years 5 months	0	1	0	0	4	0	0
1	3	7	7 years 2 months	0	1	0	0	9	1	0
2	15	21	7 years 11 months	1	7	3	1	28	14	0
3	15	27	8 years 10 months	1	3	1	0	37	14	0
4	21	21	10 years 2 months	2	7	0	0	33	12	1
5	14	26	10 years 10 months	3	4	1	1	31	10	1
Southeast										
2	10	3	8 years 1 month	0	2	0	0	11	1	0
3	6	11	8 years 11 months	0	0	0	0	17	0	0
4	8	9	10 years 10 months	0	2	0	0	15	0	0
5	4	11	11 years 1 month	0	2	0	0	13	0	0
Upper Midwest										
K	3	2	6 years 5 months	0	1	0	0	4	0	0
1	3	7	7 years 2 months	0	1	0	0	9	1	0
2	7	8	8 years 4 months	1	0	1	0	13	1	0
3	5	10	9 years 3 months	0	1	0	0	14	4	0
4	8	7	10 years 1 month	2	3	0	0	10	2	0
5	4	11	11 years 0 months	0	2	1	0	12	0	1 (not specified)
Northeast										
2	2	10	7 years 5 months	0	5	2	1	4	12	0
3	4	6	8 years 4 months	1	2	1	0	6	10	0
4	5	5	9 years 7 months	0	2	0	0	8	10	1 (speech)
5	6	4	10 years 6 months	3	0	0	1	6	10	0

Note: A=Asian, B= Black, H= Hispanic, Am= American Indian, W= White.
[a]SES indicates the number of students receiving free and reduced price lunch.

Experimenters worked individually with students in separate, quiet areas within the schools at each site. At the beginning of each session the experimenter provided a general introduction from a prepared set of directions. Students were assigned to particular levels of passages based on grade level. Students in Kindergarten and First Grades read passages in Level A. Students in second and Third Grades read passages in Level B and Fourth and Fifth Graders read passages in Level C. Passage order was random within student; each student read all passages to facilitate analysis of passage specific performances and prepare for equating and linking of passages within and across levels.

Students in Kindergarten through Fifth Grades were seen for approximately 10 successive days of testing. On each day of testing, students in second through Fifth Grades read 12 different passages and students in Kindergarten and First Grades read six passages each day. This resulted in students at Level A reading 63 total passages, and students at Levels B and C reading 120 total passages (i.e., three linking passages plus the number of progress monitoring passages for each level).

For each passage read, an appropriate paper version was placed in front of the student so s/he could read aloud. The experimenter gave directions and then followed along and scored errors on his or her paper or electronic copy for one minute. Each session lasted approximately 20 minutes. See Table 17 for descriptive statistics for the first passage reduction sample.

Table 17. Descriptive Statistics for First Passage Reduction

	M	SD	Median	Trimmed	Min	Max	Skew	Kurtosis	SE
Level A Passages									
All 60	66.63	33.08	57.30	64.89	23.88	132.0	0.51	-0.97	8.54
Reduced 40	65.47	30.97	57.83	63.88	24.83	126.8	0.50	-0.96	8.0
Level B Passages									
All 117	117.76	42.40	117.80	117.36	23.88	219.47	0.07	-0.26	5.43
Reduced 80	114.92	43.90	116.20	114.92	10.00	225.0	-0.01	-0.07	5.0
Level C Passages									
All 117	153.59	40.19	151.09	152.84	69.42	251.74	0.21	-0.34	5.37
Reduced 80	151.55	40.33	146.84	149.70	70.00	251.0	0.40	-0.29	4.79

Note. M = Mean; SD = Standard Deviation; Min = Minimum; Max = Maximum; SE = Standard Error

Second Passage Reduction

Screening. Screening took place at the beginning of the year. Due to time constraints, only one of the three screening passages were used to collect alternate form reliability coefficients. Experimenters worked individually with students in separate, quiet areas within the schools at each site. At the beginning of each session, the experimenters provided an introduction dialogue from a standardized set of directions. Each student was assessed during a single session. The appropriate paper version of the screening story was placed in front of the student so that s/he could read aloud. After instructions were delivered, the examiner followed along and scored errors on his or her copy for one minute. Each student session lasted approximately three to five minutes. Participants included students from urban and suburban schools located in the Southeast, the upper Midwest, and Northeastern regions of the United States. A passive consent procedure was used so that those students whose parents opted out of participation were excluded from the sample. The sample consisted of 1,250 students from first through Fifth Grades. Participant characteristics in the overall and disaggregated sample are provided in

Table 18.

Table 18. Demographic Information for Second Passage Reduction Sample

Grade Level	Sex		Age	Race					SES[a]	Special Education
	F	M		A	B	H	Am	W		
Overall										
K	5	5	5 years 11 months	N/A*						
1	159	157	6 years 9 months	10	51	49	3	203	21	14
2	154	164	7 years 9 months	9	41	44	3	221	23	13

3	78	118	8 years 7 months	3	40	43	2	108	33	14
4	80	107	9 years 8 months	5	21	47	1	113	18	20
5	80	83	10 years 6 months	7	33	36	2	85	23	15
Southeast**										
K	5	5	5 years 11 months	N/A*						
1	67	83	6 years 11 months	2	9	16	0	116	N/A	7
2	67	84	7 years 10 months	3	8	16	0	120	N/A	10
3	18	30	8 years 10 months	0	3	5	0	40	N/A	4
4	19	12	9 years 11 months	1	1	2	1	26	N/A	2
5	10	16	11 years 2 months	1	0	4	0	21	N/A	4
Upper Midwest										
1	58	56	6 years 10 months	3	14	28	0	69	9	17
2	57	58	7 years 8 months	6	16	28	2	63	16	14
3	44	54	8 years 9 months	3	13	33	2	47	23	30
4	38	69	9 years 10 months	3	8	40	1	55	6	25
5	41	48	10 years 5 months	4	13	30	2	40	17	21
Northeast										
1	34	18	6 years 6 months	5	21	5	0	21	12	7
2	30	22	7 years 1 month	0	15	0	0	37	7	3
3	16	34	8 years 2 months	0	24	5	0	21	10	10
4	23	26	9 years 6 months	1	12	5	0	31	12	18
5	29	19	10 years 6 months	2	20	2	0	24	6	11

Note: A=Asian, B= Black, H= Hispanic, Am= American Indian, W= White.
[a] *SES indicates the number of students receiving free or reduced price lunch.*
**Not all schools were able to provide complete information about Race, SES, or Special Education.*
***About 5% of the southeast demographics were not available and are not included in this table.*

Leveling/Anchor Process. On the first day of testing, three passages were sequentially administered to the student at the beginning of the testing session. The experimenter immediately determined the median score from these passages and compared it against the criterion points (established during screening) to determine which level of progress monitoring passages to administer. Table 19 provides the cut points used to assign students to passage difficulty level (i.e. Level A, B or C). Although students were selected across grade level, student reading levels were restricted for each passage level. Experimenters worked individually with students in separate, quiet areas within the schools at each site.

Table 19. Cut-points Used for Assigning Students to CBMreading Passage Level Based on Words Read Correct per Minute (WRC/min)

Level	Cut Point (WRC/min)
A	0 (5) to 20 (25)
B	26 to 70
C	71 to 140

Process for Administering Progress Monitoring Passages. All students read all passages to facilitate analysis of passage-specific performances and prepare for equating and linking of passages within and across levels respectively. Experimenters worked individually with students in separate, quiet areas within the schools. Students completed approximately eight successive assessment sessions.

On the first day of testing, after the child had been leveled according to the anchor passages, the experimenter also administered four to nine progress monitoring passages at the student's appropriate level. All other days of testing were used to complete administration of the progress monitoring set at the appropriate level. This resulted in students at Level A reading a total of 42 passages, and students at Levels B and C reading a total of 83 passages. All progress monitoring passages were administered randomly to each student. For each passage read, an appropriate paper version was placed in front of the student so that he or she could read aloud. The experimenter gave directions and then followed along and scored errors on the electronic or paper copy for one minute. Each session lasted approximately 15–20 minutes. See Table 20 for Descriptive Statistics.

Table 20. Descriptive Statistics for Second CBMreading Passage Reduction Sample

Passages	Mean	SD	Median	Trimmed	Min	Max	Skew	Kurtosis	SE
Level A									
Reduced 39	20.38	10.46	18.33	19.39	4.54	56.18	0.94	0.87	1.04
Reduced 30	19.54	9.96	17.55	18.60	4.40	55.30	0.99	1.16	0.99
Level B									
Reduced 80	52.20	16.40	52.19	51.92	15.96	102.65	0.20	-0.18	1.13
Reduced 60	51.24	15.83	50.90	50.93	16.00	101.00	0.24	-0.06	1.09
Reduced 30	52.33	15.34	52.08	52.13	17.00	99.50	0.17	-0.20	1.06
Level C									
Reduced 80	103.04	26.09	103.05	102.65	42.24	195.83	0.20	-0.21	1.32
Reduced 60	102.96	25.25	102.95	102.54	43.87	194.53	0.21	-0.15	1.28
Reduced 30	104.68	24.41	104.70	104.29	46.80	195.37	0.22	-0.10	1.24

Table 21 summarizes information accumulated across several studies. Data was collected from three states: Minnesota, New York, and Georgia. The information represents evidence for alternate form reliability of CBMreading, and overall reliability of the performance level score.

Table 21. Alternate Form Reliability and SE*m* for CBMreading (Restriction of Range)

Grade and Passage	# of passages	# of Weeks	Coefficient[a]		
			Range	Median	SE*m*
Passage Level A (Grade 1)	39	< 2	.62 - .86	.74	5.40
Grade 1 (206)					
Grade 2 (21)					
Grade 3 (4)					
Total N 231					

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Passage Level B (Grades 2–3)	60	< 2	.65 - .82	.75	8.54
Grade 1 (138)					
Grade 2 (179)					
Grade 3 (126)					
Grade 4 (32)					
Grade 5 (13)					
Total N 488					
Passage Level C (Grades 4–6)	60	< 2	.78 - .88	.83	10.41
Grade 1 (3)					
Grade 2 (135)					
Grade 3 (79)					
Grade 4 (156)					
Grade 5 (140)					
Total N 513					
Passage Level A (Grade 1)	39	< 2	.89 - .94	.92	3.03
Grade (206)					
Grade (21)					
Grade 3 (4)					
Total N 231					
Passage Level B (Grades 2–3)	60	<2	.87 - .92	.90	4.97
Grade 1 (138)					
Grade 2 (179)					
Grade 3 (126)					
Grade 4 (32)					
Grade 5 (13)					
Total N 488					
Passage Level C (Grades 4–6)	60	< 2	.92 - .95	.94	7.06
Grade 1 (3)					
Grade 2 (135)					
Grade 3 (79)					
Grade 4 (156)					
Grade 5 (140)					
Total N 513					

*Note: Alternate-Form Correlation – Individual Passages (Average Fisher z-transformed Inter-Passage Correlations). Sample sizes by grade level are provided in parentheses. *Coefficients are reduced due to restriction of range. SEm estimates are equivalent to published research (viz. Christ & Silberglitt, 2007; Wayman et al., 2007).*

Internal Consistency (Item-Total Correlation)

Data collection for internal consistency is ongoing. Evidence of CBMreading internal consistency across passages is provided in the table below. Similar to alternate-form reliability, information was gathered across three states: Minnesota, New York, and Georgia. Table 22 provides evidence of the reliability of the performance level score.

Table 22. Internal Consistency for CBMreading Passages

Passage and Grade	# of Passages	# of Weeks	Coefficient Range	Coefficient Median
Passage Level A (Designed for Grade 1)	60	< 2	.91 - .92	.92
Grade 1(206)				
Grade 2 (21)				
Grade 3 (4)				
Total N 231				
Passage Level B (Designed for Grades 2 & 3)	60	< 2	.89 - .91	.90
Grade 1 (138)				
Grade 2 (179)				
Grade 3 (126)				
Grade 4 (32)				
Grade 5 (13)				
Total N 488				
Passage Level C (Designed for Grades 4-6)	60	< 2	.88 - .93	.91
Grade 1 (3)				
Grade 2 (135)				
Grade 3 (79)				
Grade 4 (156)				
Grade 5 (140)				
Total N 513				

Note. Sample sizes by grade level are provided in parentheses.

[a] *Coefficients are reduced due to restriction of range. Participants were selected from a very narrow (low) ability range to evaluate reliability with the intended population. SEm estimates are equivalent to those observed in published research (viz. Christ & Silberglitt, 2007; Wayman et al., 2007).*

See Table 23 below for evidence of split-half reliability for CBMreading passages.

Table 23. Split-Half Reliability for CBMreading passages

Grade	N	Range	Median
Grades 1st	500	.90 to .98	> .95
Grades 2 & 3	500	.90 to .98	> .95
Grades 4 to 6	500	.90 to .98	> .95

Test-Retest Reliability (Delayed)

Table 24 provides evidence of the reliability of the performance level score. Data was gathered across three states: Minnesota, New York, and Georgia. The reliability range coefficients have been computed with a 95% confidence interval. In addition, for the time lag, the mean number of weeks between data collections is reported.

Table 24. Evidence for Delayed Test-Retest Reliability of CBMreading

			# Weeks Lag		Coefficient	
Grade	N	Time Period	Mean	SD	Range	Median
1	428	Fall to Winter	18.68	3.03	.88 - .92	.90
2	414	Fall to Winter	18.56	2.44	.91 - .94	.93
3	435	Fall to Winter	18.98	2.50	.92 - .94	.93
4	475	Fall to Winter	19.00	2.32	.93 - .95	.94
5	481	Fall to Winter	19.00	2.51	.92 - .94	.93
6	220	Fall to Winter	17.45	0.86	.92 - .95	.94
1	408	Fall to Spring	35.57	2.02	.79 - .85	.82
2	386	Fall to Spring	35.93	1.61	.87 - .91	.90
3	403	Fall to Spring	35.79	1.47	.89 - .93	.91
4	406	Fall to Spring	35.67	1.41	.91 - .94	.93
5	411	Fall to Spring	35.67	1.41	.92 - .94	.93
6	218	Fall to Spring	35.01	0.96	.90 - .94	.92

Note. SD = Standard Deviation.

Table 25 provides evidence of delayed test-retest reliability, disaggregated by ethnicity. The sample included students from urban, suburban, and rural areas in Minnesota.

Table 25. CBMreading Delayed Test-Retest Reliability Disaggregated by Ethnicity

Grade	N	Time Period	# Weeks Lag	Coefficient Range	Coefficient Median	Ethnicity
2	1518	Fall to Winter	14	.91 - .92	.91	White
2	369	Fall to Winter	14	.90 - .94	.92	Black
2	210	Fall to Winter	14	.92 - .95	.94	Asian
2	308	Fall to Winter	14	.91 - .94	.93	Hispanic
3	1439	Fall to Winter	14	.91 - .92	.92	White
3	442	Fall to Winter	14	.90 - .93	.91	Black
3	197	Fall to Winter	14	.87 - .92	.90	Asian
3	314	Fall to Winter	14	.91 - .94	.93	Hispanic
4	1384	Fall to Winter	14	.88 - .91	.90	White
4	353	Fall to Winter	14	.89 - .92	.91	Black
4	204	Fall to Winter	14	.89 - .94	.92	Asian
4	268	Fall to Winter	14	.87 - .92	.90	Hispanic
5	1309	Fall to Winter	14	.91 - .93	.92	White
5	378	Fall to Winter	14	.91 - .94	.93	Black
5	205	Fall to Winter	14	.89 - .93	.91	Asian
5	247	Fall to Winter	14	.91 - .95	.93	Hispanic
2	1518	Fall to Spring	31	.83 - .86	.85	White
2	369	Fall to Spring	31	.75 - .83	.79	Black
2	210	Fall to Spring	31	.81 - .88	.85	Asian
2	308	Fall to Spring	31	.76 - .84	.80	Hispanic
3	1439	Fall to Spring	31	.88 - .90	.89	White
3	442	Fall to Spring	31	.82 - .87	.85	Black
3	197	Fall to Spring	31	.80 - .88	.84	Asian
3	314	Fall to Spring	31	.80 - .87	.84	Hispanic
4	1384	Fall to Spring	31	.85 - .88	.87	White
4	353	Fall to Spring	31	.82 - .88	.85	Black
4	204	Fall to Spring	31	.80 -.88	.85	Asian
4	268	Fall to Spring	31	.81 - .88	.85	Hispanic
5	1309	Fall to Spring	31	.87 - .90	.88	White
5	378	Fall to Spring	31	.77 - .84	.81	Black
5	205	Fall to Spring	31	.83 - .89	.86	Asian
5	247	Fall to Spring	31	.84 - .90	.87	Hispanic

Inter-Rater Reliability

Inter-rater reliability evidence was collected across three states: Minnesota, New York, and Georgia. See Table 26.

Table 26. Evidence of Inter-Rater Reliability for CBMreading

Passage	Sample Size	Coefficient Range	Coefficient Median
Passage Level A	146	.83 – 1.00	.97
Passage Level B	1391	.93 - 97	.97
Passage Level C	1345	.83 – 1.00	.98

Reliability of the Slope

Some may argue that alternate-form reliabilities may not accurately capture reliability of the slope due to the small amount of variation in slope values, represented by low standard error of the estimate and standard error of the slope values. This might be a result of the structure of passage administration (Levels vs. Grades). By using passage levels as groups instead of grades, we may be reducing variability within grades, decreasing the reliability of slope estimates. The following analysis was conducted using HLM 7 software and used random slopes and random intercepts (See Table 27).

Table 27. Reliability of the Slope for CBMreading

Sample Size by Passage	Weeks	Observations	Coefficient Range	Coefficient Median
Passage Level A				
N=34	~ 27 - 30	~25-30	NA	.95
N=39	~ 7 -10	~7-10	NA	.78
Passage Level B				
N=53	~ 27 - 30	~25-30	NA	.98
	~ 7 -10	~7-10	NA	.97
Passage Level C				
	~ 27 - 30	~25-30	NA	.98
	~ 7 -10	~7-10	NA	.97

Table 28 provides a summary for reliability of the slope by grade (passage) level. Reliability of the slope for multi-level analyses may be biased when standard error of the estimate and standard error of the slope is minimal. CBMreading growth estimates are less prone to error than comparable progress monitoring materials. As a result, increased precision (less error) is paradoxically detrimental to multi-level reliability estimates (Raudenbush & Bryk, 2002). In such circumstances, the spearman brown correlation is more appropriate. The following information includes participants across three states: Minnesota, New York, and Georgia.

Table 28. Reliability of the Slope of CBMreading by Passage using Spearman-Brown Split Half Correlation

Passage Level	Weeks (range)	Coefficient	SE*m*
Passage Level A	Short Term	.71	.40
Grade 1 (68)	10		
Grade 2 (12)			
Grade 3 (2)			
Total N = 82			
Passage Level B	Short Term	.74	.31
Grade 1 (7)	10 - 20		
Grade 2 (72)			
Grade 3 (53)			
Grade 4 (12)			
Grade 5 (6)			
Grade 6 (1)			
Total N = 151			
Passage Level C	Short Term	.65	.30
Grade 2 (3)	6 - 20		
Grade 3 (31)			
Grade 4 (81)			
Grade 5 (68)			
Grade 6 (28)			
Total N = 211			
Passage Level A	Long Term	.95	.21
Grade 1 (42)	14 - 30		
Grade 2 (15)			
Grade 3 (4)			
Total N = 61			
Passage Level B	Long Term	.70	.31
Grade 1 (6)	14 - 30		
Grade 2 (41)			
Grade 3 (38)			
Grade 4 (15)			
Grade 5 (8)			
Grade 6 (1)			
Total N = 109			
Passage Level C	Long Term	.66	.32
Grade 2 (2)	18 - 30		
Grade 3 (19)			
Grade 4 (49)			
Grade 5 (44)			
Grade 6 (23)			
Total N = 137			

Note. Sample sizes by grade level are provided in parentheses. SEm = |Even – Odd| / sqrt(2)

Table 29 provides reliability of the slope evidence derived from multi-level analyses, strictly using true slope variance divided by total slope variance. The following information includes participants across three states: Minnesota, New York, and Georgia.

Table 29. Reliability of the Slope for CBMreading by Passage Using Multi-Level Analyses

Passage Level	Weeks (range)	Coefficient
Passage Level A	Short Term	.75
Grade 1 (68)	10	
Grade 2 (12)		
Grade 3 (2)		
Total N = 82		
Passage Level B	Short Term	.74
Grade 1 (7)	10–20	
Grade 2 (72)		
Grade 3 (53)		
Grade 4 (12)		
Grade 5 (6)		
Grade 6 (1)		
Total N = 151		
Passage Level C	Short Term	.63
Grade 2 (3)	6–20	
Grade 3 (31)		
Grade 4 (81)		
Grade 5 (68)		
Grade 6 (28)		
Total N = 211		
Passage Level A	Long Term	.94
Grade 1 (42)	14–30	
Grade 2 (15)		
Grade 3 (4)		
Total N = 61		
Passage Level B	Long Term	.86
Grade 1 (6)	14–30	
Grade 2 (41)		
Grade 3 (38)		
Grade 4 (15)		
Grade 5 (8)		
Grade 6 (1)		
Total N = 109		
Passage Level C	Long Term	.45
Grade 2 (2)	18–30	
Grade 3 (19)		
Grade 4 (49)		
Grade 5 (44)		
Grade 6 (23)		
Total N = 137		

Table 30 provides evidence of reliability of the slope disaggregated by ethnicity. Participants included those from Minnesota. Reliability of the slope for multi-level analyses may be biased when few observations are used to estimate slope. In this instance, slopes were estimated from tri-annual assessments (3 observations). Coefficients should be interpreted with caution (Raudenbush & Bryk, 2002). The sample included students from urban, suburban, and rural areas of Minnesota.

Table 30. CBMreading Reliability of the Slope - Disaggregated Data

Grade	N (range)	Coefficient		Ethnicity
		Range	Median	
Grades 2–5	1308–1518	.25 - .43	.28	White
Grades 2–5	353–442	.32 - .60	.43	Black
Grades 2–5	197–210	.38 - .52	.40	Asian
Grades 2–5	247– 314	.21 - .52	.45	Hispanic

aReading

The following sections provide a discussion of types of reliability obtained for aReading, as well as sources of error. Data collection regarding reliability of the slope is ongoing.

Alternate-Form Reliability

Given the adaptive nature of aReading tests, a proxy for alternate-form reliability is provided by Samejima (1994), based on the standard error of measurement of an instrument. Using this proxy, the alternate-forms reliability coefficient for aReading is approximately .95 (based on approximately 2,333 students).

Internal Consistency (Item-Total Correlations)

Given the adaptive nature of aReading tests, a proxy for internal consistency is provided by Samejima (1994), based on the standard error of measurement of an instrument. Using this proxy, the internal consistency reliability coefficient for aReading is approximately .95 (based on approximately 2,333 students).

Test-Retest Reliability

Three month test-retest reliability resulted in the following coefficients for 2,038 students in grades 1 - 5 (Kindergarten and grades 6–12 results are coming soon). Growth was measured four times over the academic year. The results by grade: one .71, two .87, three .81, four .86, five .75.

Chapter 2.6: Validation

earlyReading

Evidence for validity of the earlyReading subtest measures was examined using the Group Reading Assessment and Diagnostic Evaluation (GRADE; Williams, 2001). The GRADE™ is a norm-referenced diagnostic reading assessment that assists teachers in measuring pre-literacy, emerging reading and core reading skills, as well as providing teachers with implications for instruction and intervention.

Content Validity

The design specifications for earlyReading measures relate directly to their evidence of content validity. Each subtest was designed with the intent to address specific criteria aimed to maximize both utility and sensitivity.

earlyReading	**K**			**1st**			**Common Core State Standards**	**State Specific Standards**
Measures	F	W	S	F	W	S		
Concepts of Print	■						RF.K1, RF.K.1.a, RF.K.1.b, RF.K.1.c, RF.1.1, F.1.1.a	
Letter Names	■	■					RF.K.1.d	
Letter Sounds		■	■				RF.K.3.a	
Decodable Words		O	O	O	O	O	R.F.K.3, RF.1.3, RF.1.3.b, RF.2.3, RF.3.3	
Nonsense Words		■	■	■	■	■	R.F.K.3, RF.1.3, RF.1.3.b, RF.2.3, RF.3.3	
Sight Words (50) Sight Words (150)			■	■	■	■	RF.K.3.c, RF.1.3.g, R.2.3.f, RF.3.3.d	Available upon request
Sentence Reading (CBM W, S)				■	■	■	RF.K.4, RF.1.4, RF.1.4.b, RF.2.4, RF.2.4.b, RF.3.4	
Onset Sounds							RF.K.2.c, RF.K.2.D, RF.1.2.c	
Rhyming							RF.K.2.a	
Word Blending							RF.K.2.b, RF.K.2.c, RF.1.2.b	
Word Segmenting		■	■	■	■	■	RF.K.2.b, RF.K.2.d, RF.1.2.c, RF.1.2.d	
Oral Repetition							SL.K.6, SL.1.6	
Composite Broad Score	■ – recommended screening tools and composition of broad composite score O – Optional measure to replace nonsense words							

Criterion-Related Validity

Criterion-related validity of earlyReading subtests was examined using the GRADE™. The GRADE is an untimed, group-administered, norm-referenced reading achievement test that is intended for children in preschool through grade 12. Comprised of 16 subtests categorized within five components, the GRADE utilizes particular subtest scores, depending on the testing level, to form the Total Test composite score. Evidence for the validity of earlyReading is presented below on the external criterion measure of the GRADE Total Test composite score. Validity is most often represented as a correlation between the assessment and the criterion. Both concurrent and predictive validity are reported for all earlyReading measures, where available (See Table 33).

In order to establish criterion-related validity, students were recruited from school districts. In School District 1, three elementary schools participated. Kindergarten students from District 1 who participated in the study were enrolled in all-day or half-day Kindergarten. The majority of students within the school district were White (78%), with the remaining students identified as either Black (19%), or other (3%). Forty to fifty percent of students at each school were eligible for free and reduced lunch. In school District 2, the majority of students within the school district were White (53%), with the remaining students identified as Black (26%), Hispanic (11%), Asian (8%), or other (2%). Forty to fifty percent of students at each school are on free and reduced lunch.

Students in Kindergarten were administered FAST™ earlyReading Concepts of Print, Onset Sounds, Letter Naming, Letter Sound, Rhyming, Word Blending, Word Segmenting, Sight Words (50), Nonsense Words, and Decodable Words subtests. Students in First Grade were administered FAST™ earlyReading Word Blending, Word Segmenting, Sight Words (150), Decodable Words, Nonsense Word, and Sentence Reading subtests. Teachers administered six to nine measures at each screening period (fall, winter, and spring). See Table 31 for demographic information about the sample from which earlyReading composite validity coefficients were derived, including predictive and concurrent validity. Sample-related information for criterion-related validity data is provided in

Table 32. Predictive and concurrent validity coefficients are reported in Table 33.

Table 31. Demographics for Criterion-Related Validity Sample for earlyReading Composite Scores

Category	District A	District B
White	78%	53%
Black	19%	26%
Hispanic	--	11%
Asian/Pacific Islander	--	8%
Other	3%	2%
Free/Reduced Lunch	40-50%	

Table 32. Sample-Related Information for Criterion-Related Validity Data (earlyReading)

Measure	Fall			Winter			Spring		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Kindergarten									
Concepts of Print	230	8.41	2.41	58	9.43	2.14	--	--	--
Onset Sounds	230	12.28	4.17	216	15.06	2.04	155	15.70	1.61
Letter Naming	230	28.57	15.60	210	39.51	13.35	230	54.80	18.40
Letter Sound	230	15.56	11.69	210	29.20	13.74	230	43.10	15.51
Rhyming	230	9.47	4.97	224	12.01	4.62	229	14.28	3.15
Word Blending	230	3.19	3.67	227	6.76	3.36	228	9.14	1.79
Word Segmenting	91	6.34	9.68	228	19.35	12.89	228	30.11	6.17
Decodable Words	--	--	--	--	--	--	228	16.04	15.15
Nonsense Words	--	--	--	2281	7.19	6.73	229	13.16	10.71

Sight Words 50	--	--	--	--	--	--	227	44.29	29.38
Composite	173	40.78	9.91	173	49.41	13.74	173	59.79	14.37
First Grade									
Word Blending	179	7.42	2.41	169	8.80	2.14	172	9.30	1.38
Word Segmenting	179	26.84	4.17	168	30.10	2.04	172	30.91	4.40
Decodable Words	179	14.43	15.60	168	26.19	13.35	186	40.80	21.12
Nonsense Words	179	10.91	11.69	166	20.69	13.74	131	24.26	14.31
Sight Words 150	179	34.57	4.97	168	60.10	4.62	173	77.03	21.93
Sentence Reading	179	43.89	3.67	30	67.62	3.36	--	--	--
CBM-R	--	--	--	183	75.48	42.55	188	104.00	43.19
Composite	100	39.06	10.39	100	48.07	10.50	100	62.87	12.94

Note. [1]*Nonsense words in the winter used partially imputed values.*

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Table 33. Concurrent and Predictive Validity for all earlyReading Measures

Type of Validity	Grade	Criterion	N	Coefficient	Information
Onset Sounds					
Concurrent	K	GRADE^{P}	85	.62	Data collected in Fall
Predictive	K	GRADE^{K}	230	.55	Fall to Spring prediction
Predictive	K	GRADE^{K}	216	.60	Winter to Spring prediction
Concurrent	K	GRADE^{K}	140	.03	Data collected in Spring
Letter Names					
Concurrent	K	GRADE^{P}	85	.41	Data collected in Fall
Predictive	K	GRADE^{K}	230	.47	Fall to Spring prediction
Predictive	K	GRADE^{K}	210	.63	Winter to Spring prediction
Concurrent	K	GRADE^{K}	214	.18	Data collected in Spring
Letter Sounds					
Concurrent	K	GRADE^{P}	85	.53	Data collected in Fall
Predictive	K	GRADE^{K}	230	.44	Fall to Spring prediction
Predictive	K	GRADE^{K}	210	.63	Winter to Spring prediction
Concurrent	K	GRADE^{K}	214	.19	Data collected in Spring
Word Blending					
Predictive	K	GRADE^{K}	227	.66	Winter to Spring prediction
Predictive	K	GRADE^{K}	230	.41	Fall to Spring prediction
Concurrent	K	GRADE^{K}	213	.23	Data collected in Spring
Concurrent	1	GRADE^{1}	71	.22	Data collected in Fall
Predictive	1	GRADE^{1}	179	.56	Fall to Spring prediction
Predictive	1	GRADE^{1}	169	.53	Winter to Spring prediction
Concurrent	1	GRADE^{1}	165	.12	Data collected in Spring
Word Segmenting					
Predictive	K	GRADE^{K}	228	.58	Winter to Spring prediction
Concurrent	K	GRADE^{K}	213	.25	Data collected in Spring
Concurrent	1	GRADE^{1}	71	.49	Data collected in Fall
Predictive	1	GRADE^{1}	179	.32	Fall to Spring prediction
Predictive	1	GRADE^{1}	168	.60	Winter to Spring prediction
Concurrent	1	GRADE^{1}	165	.07	Data collected in Spring
Decodable Words					
Concurrent	K	GRADE^{K}	214	.27	Data collected in Spring
Concurrent	1	GRADE^{1}	71	.22	Data collected in Fall
Predictive	1	GRADE^{1}	179	.59	Fall to Spring prediction
Predictive	1	GRADE^{1}	168	.78	Winter to Spring prediction
Concurrent	1	GRADE^{1}	124	.46	Data collected in Spring
Sight Words 50					
Concurrent	K	GRADE^{K}	213	.19	Data collected in Spring

Type of Validity	Grade	Criterion	N	Coefficient	Information
Sight Words 150					
Concurrent	1	GRADE^{1}	71	.59	Data collected in Fall
Predictive	1	GRADE^{1}	179	.66	Fall to Spring prediction
Predictive	1	GRADE^{1}	168	.80	Winter to Spring prediction
Predictive	1	GRADE^{1}	179	.66	Fall to Spring prediction
Concurrent	1	GRADE^{1}	166	.43	Data collected in Spring
Nonsense Words					
Predictive	K	GRADE^{K}	105	.44	Winter to Spring prediction
Concurrent	K	GRADE^{K}	215	.27	Data collected in Spring
Predictive	1	GRADE^{1}	179	.60	Fall to Spring prediction
Predictive	1	GRADE^{1}	168	.67	Winter to Spring prediction
Concurrent	1	GRADE^{1}	179	.43	Data collected in Spring
Composite					
Predictive	K	GRADE^{K}	173	.68	Fall to Spring prediction
Predictive	K	GRADE^{K}	173	.69	Winter to Spring prediction
Concurrent	K	GRADE^{K}	173	.67	Data collected in Spring
Predictive	1	GRADE^{1}	100	.72	Fall to Spring prediction
Predictive	1	GRADE^{1}	100	.81	Winter to Spring prediction
Concurrent	1	GRADE^{1}	100	.83	Data collected in Spring

Note. All criterion coefficients were determined using the composite of the GRADE. Level is indicated in superscript. For example, GRADE^{P} represents GRADE Composite Level P.

More recently, criterion-related validity analyses was estimated for spring earlyReading composite scores to predict spring aReading scores. These findings are summarized in the table below. Students were recruited from several school districts in Minnesota. Cut score was selected by optimizing sensitivity at about .70 and balancing sensitivity with specificity (Silberglitt & Hintze, 2005). In the table below, dashes indicate unacceptable sensitivity and specificity due to low AUC. Criterion coefficients ranged from .74 to .77.

Table 34. Criterion Validity of Spring earlyReading Composite (Updated weighting scheme) with Spring aReading: MN LEA 3 (Spring Data Collection)

Grade	N	Composite	aReading	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (<40th percentile)								
KG	515	62.41 (12.53)	415.59 (27.13)	.74**	64.5	.87	.77	.80
1	169	56.08 (15.79)	459 (27.34)	.77**	--	.65	--	--
High Risk (<20th percentile)								
KG	515	62.41 (12.53)	415.59 (27.13)	.74**	61.5	.84	.76	.73
1	169	56.08 (15.79)	459 (27.34)	.77**	51.5	.72	.70	.59

Predictive Validity of the Slope

Validity of earlyReading subtests were examined using the GRADE. Table 31 presents the demographic information from which the sample was derived, as this sample served multiple purposes in establishing validity evidence for earlyReading.

Table 35 presents the correlation between the slope of performance using screening data (i.e., students were assessed three times per year, fall, winter and spring) and performance on the GRADE. All correlations account for initial level of performance.

Table 35. Predictive Validity of the Slope for All earlyReading Measures

Measure	Grade	Criterion	N	Coefficient
Onset Sounds	K	$GRADE^K$	217	.29
Letter Names	K	$GRADE^K$	231	.44
Letter Sounds	K	$GRADE^K$	231	.54
Word Blending	K	$GRADE^K$	230	.48
Word Blending	1	$GRADE^1$	178	.16
Word Segmenting	K	$GRADE^K$	224	.49
Word Segmenting	1	$GRADE^1$	178	.23
Decodable Words	1	$GRADE^1$	179	.62
Sight Words (150)	1	$GRADE^1$	180	.59
Nonsense Words	1	$GRADE^1$	174	.61

Note. All coefficients were determined using the composite of the GRADE. Level is indicated in superscript. For example, $GRADE^P$ represents GRADE Composite Level P.

Discriminant Validity

See Table 13 for demographic information on the sample. This study provided data for both reliability of the slope and discriminant validity evidence for earlyReading measures. Table 36 and Table 37 display discriminant validity for earlyReading subtests in Kindergarten and First Grade, respectively.

Table 36. Discriminant Validity for Kindergarten earlyReading Measures

Measure by	Below 40th Percentile			Above 40th Percentile			Difference Stats	
Time of Year	N	Mean	SD	N	Mean	SD	t	d
Concepts of Print								
Beginning	204	6.42	1.60	240	10.29	1.08	30.24	2.88
Middle	-	-	-	-	-	-	-	-
End	-	-	-	-	-	-	-	-
Onset Sounds								
Beginning	185	7.78	3.41	259	15.09	1.04	32.46	3.09
Middle	417	14.78	2.55	0	NA	NA	-	-
End	-	-	-	-	-	-	-	-
Letter Naming								
Beginning	182	10.38	7.76	262	38.68	9.01	34.42	3.27
Middle	182	25.45	11.34	242	49.20	3.54	30.66	2.99

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End	193	34.62	12.55	271	65.98	28.85	14.17	1.32
Letter Sound								
Beginning	187	3.77	3.48	257	23.81	10.40	25.33	2.41
Middle	173	14.16	7.85	251	36.82	8.58	27.66	2.69
End	212	26.13	10.65	252	51.85	10.90	25.59	2.38
Rhyming								
Beginning	191	4.34	2.73	253	13.12	2.33	36.50	3.47
Middle	194	8.29	4.17	222	15.41	0.74	25.00	2.46
End	224	11.38	3.97	238	16.00	0.00	17.95	1.67
Word Blending								
Beginning	209	0.00	0.00	234	5.85	2.92	28.96	2.76
Middle	179	2.29	2.18	254	8.93	1.09	41.72	4.02
End	206	6.50	2.97	256	10.00	0.00	18.86	1.76
Word Segmenting								
Beginning	-	-	-	-	-	-	-	-
Middle	174	5.63	5.68	260	29.04	4.31	48.73	4.69
End	194	21.50	9.34	268	33.03	1.10	20.03	1.87
Decodable Words								
Beginning	-	-	-	-	-	-	-	-
Middle	-	-	-	-	-	-	-	-
End	184	2.72	2.43	275	23.32	16.03	17.29	1.62
Nonsense Words								
Beginning	-	-	-	-	-	-	-	-
Middle	107	1.01	1.01	142	12.23	9.47	12.20	1.55
End	191	3.53	2.86	269	19.80	12.33	17.96	1.68
Sight Words (50)								
Beginning	-	-	-	-	-	-	-	-
Middle	-	-	-	-	-	-	-	-
End	177	9.58	7.29	253	57.66	22.59	27.33	2.64

Table 37. Discriminant Validity for First Grade earlyReading Subtests

Measure by Time of Year	Below 40th Percentile			Above 40th Percentile			Difference Stats	
	N	Mean	SD	N	Mean	SD	t	d
Word Blending								
Beginning	253	4.39	2.47	357	9.13	0.81	33.79	2.74
Middle	276	7.78	2.10	344	10	0	19.61	1.58
End	-	-	-	-	-	-	-	-
Word Segmenting								
Beginning	252	17.89	7.62	358	30.67	2.15	30.09	2.44
Middle	278	27.38	5.47	340	33.22	10.79	8.23	0.66
End	269	26.84	5.60	356	33.35	0.78	21.66	1.74
Decodable Words								
Beginning	256	2.92	1.93	343	19.65	13.78	19.28	1.58
Middle	265	11.29	4.92	353	34.22	10.79	32.17	2.59
End	262	17.88	7.74	386	51.37	15.19	32.9	2.59
Nonsense Words								
Beginning	283	3.88	2.29	316	16.06	9.02	22.09	1.81
Middle	221	10.39	3.82	292	26.98	10.82	21.79	1.93
End	240	12.78	5.00	343	35.31	12.52	26.44	2.19

Sight 150								
Beginning	248	6.48	4.06	351	44.94	19.92	29.96	2.45
Middle	191	30.66	15.19	268	73.71	15.90	29.13	2.73
End	253	48.48	17.54	379	88.47	14.44	31.27	2.49
Sentence Reading								
Beginning	223	12.77	4.98	332	57.05	37.68	17.44	1.48
Middle	-	-	-	-	-	-	-	-
End	-	-	-	-	-	-	-	-

CBMreading

Evidence for validity of the CBMreading passages was examined using the Test of Silent Reading Efficiency and Comprehension (TOSREC), the Group Reading Assessment and Diagnostic Evaluation (GRADE), Measures of Academic Progress (MAP), AIMSweb Reading CBM (R-CBM), and the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Next. The TOSREC is a brief test of reading that assesses silent reading of connected text for comprehension. The TOSREC can be used for screening purposes, as well as for monitoring progress. The GRADE is a norm-referenced diagnostic reading assessment that assists teachers in measuring pre-literacy skills, emerging reading skills, and core reading skills, as well as providing teachers with implications for instruction and intervention. MAP is a compilation of computerized adaptive assessments used to benchmark student growth and to serve as a universal screener. AIMSweb is web-based and may be used for universal screening, monitoring progress, and managing data for students in Kindergarten through twelfth grade. Like CBMreading, AIMSweb Reading CBM probes are intended to measure oral reading fluency and provide an indicator of general reading achievement. Finally, DIBELS Next are a set of procedures and measures for assessing the acquisition of early literacy skills from Kindergarten through Sixth Grade. DIBELS Next was designed to serve as a measure of oral reading fluency and a method for monitoring the development of early literacy and early reading skills. Data collection to gather evidence of discriminant validity is ongoing.

Content Validity

The design specifications for CBMreading relate directly to their evidence of content validity. Each passage set was designed with the intent to address specific criteria aimed to maximize both utility and sensitivity. Specific guidelines were provided for paragraph and sentence structure. This was necessary to ensure a parallel text structure across the passages. Each writer was instructed to use three or four paragraphs within each passage and, when possible, include a main idea sentence at the beginning of each paragraph that would introduce and help organize content for the reader. Writers were also instructed to not use complex punctuation such as colons and semi-colons in order to reflect text that is familiar to primary grade levels as well as to encourage a more direct style of writing.

The passages developed for the Grade 1 passages (Level A) could include 150–200 words overall in 2–5 paragraphs. Sentences were structured to stay within a range of 3–7 words. Each paragraph was strictly structured to stay within a range of 7–15 sentences. The number of words per sentence and sentences per paragraph were varied across the story to result in the appropriate total number of words.

Passages developed for Grades 2 and 3 (Level B) could include between 230–300 words overall. Sentences were structured to stay within a range of 6–11 words. Each paragraph was strictly structured to stay within a range of 3–7 sentences. The number of words per sentence and sentences per paragraph were varied across the story to result in the appropriate total number of words (i.e., 230–300).

The passages developed for Grades 4 through 6 (Level C) could include between 240–300 words overall. Sentences were strictly structured to stay within a range of 7–11 words. Each paragraph was strictly structured to stay within a range of 3–7 sentences. In addition, the 2nd or 3rd sentence of each paragraph of these passages was required to be a longer sentence, specifically from 12–19 words in length. Once again, the number of words per sentence and sentences per paragraph were varied across the story to result in the appropriate total number of words (i.e., 240–300). Overall evidence supports that guidelines for development were accurately addressed and provided the FAST™ team with passages that were consistent at each level in the full and reduced passage sets.

Criterion-Related Validity

Predictive and concurrent criterion validity for each grade level are available using a number of different tests or criterion (i.e., TOSREC, MAP, AIMSweb and DIBELS Next), providing evidence of criterion-related validity. Where applicable, the delay between CBMreading administration and criterion administration is stated. Students scoring in the lower 40th percentile during screening were assigned to either the long- or short-term condition. Approximately 20% of the students were targeted within Level 1, 40% in Level 2, and 40% in Level 3. When possible, participants were selected to ensure they read at the lower end of each score range for Level 1, 2, and 3, respectively. This methodological constraint ensured that the students wouldn't grow out of the range of equitable scores across the time of data collection, which spanned two years.

Concurrent and Predictive Validity for CBMreading Grade-Level Passages is provided in Table 38. All coefficients were derived from students across three states: Minnesota, New York, and Georgia.

Table 38. Concurrent and Predictive Validity for CBMreading

Type of Validity	Grade	Criterion	N	Time Lapse (Weeks)		Coefficient
				M	SD	
Concurrent	1	TOSREC	218			.86
	2		246			.81
	3		233			.81
	4		228			.79
	5		244			.81
	6		222			.82
Concurrent	1	DIBELS NEXT	399			.95
	2		463			.92
	3		483			.96
	4		485			.95
	5		503			.95
	6		225			.95
Concurrent	1	AIMSweb	399			.95

	2		425			.97
	3		402			.95
	4		445			.96
	5		447			.96
	6		229			.95
Concurrent	2	MAP	237			.81
	3		231			.78
	4		233			.73
	5		219			.66
	6		212			.69
Predictive	1	AIMSweb	385	18.68	3.04	.91
	2		413	18.56	2.44	.93
	3		391	18.98	2.50	.91
	4		427	19	2.32	.94
	5		431	19	2.51	.93
	6		220	17.45	.86	.94
Predictive	1	DIBELS	425	35.57	2.02	.82
	2	Next	80	35.93	1.61	.74
	3		76	35.79	1.47	.91
	4		74	35.67	1.41	.90
	5		85	35.67	1.41	.93
Predictive	1	TOSREC	44	35.57	2.02	.47
	2		35	35.94	1.61	.56
	3		33	35.79	1.48	.69
	4		35	35.67	1.41	.52
	6		18	35.06	.96	.87
Predictive	2	MAP	240	35.23	1.42	.76
	3		233	35.47	1.27	.73
	4		235	35.23	.88	.69
	5		220	35.29	1.13	.65
	6		212	35.06	.96	.71

Note. SD = Standard Deviation; M = Mean.

Additional criterion-related validity evidence for CBMreading is summarized below.

Table 39. Criterion Validity of Spring CBMreading with Spring CRCT in Reading: GA LEA 1 (Spring Data Collection)

Grade	N	CBMreading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	324	115.74 (43)	848.62 (28)	.61*	113.50	.77	.71	.70
4	310	135.74 (39)	848.30 (27)	.61*	131.50	.79	.71	.73
5	343	148.01 (38)	841.27 (25)	56*	151.50	.73	.69	.69
High Risk (Does Not Meet Standards)								
3	324	115.74 (43)	848.62 (28)	.61*	79.00	.89	.80	.84
4	310	135.74 (39)	848.30 (27)	.61*	99.50	.89	.83	.83
5	343	148.01 (38)	841.27 (25)	56*	122.50	.81	.77	.77

Table 40. Criterion Validity of Spring CBMreading with Spring MCA-III in Reading: MN LEA 4 (Spring Data Collection)

Grade	N	CBM-R M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does not Meet or Partially Meets Standards)								
3	852	139 (40)	348 (20)	.76	141.5	.86	.78	.76
4	818	165 (39)	447 (15)	.71	164.5	.83	.75	.71
5	771	165 (40)	552 (16)	.70	163.5	.84	.77	.76
High Risk (Does Not Meet Standards)								
3	852	139 (40)	348 (20)	.76	131.5	.88	.80	.79
4	818	165 (39)	447 (15)	.71	153.5	.87	.80	.78
5	771	165 (40)	552 (16)	.70	151.5	.89	.80	.79

Table 41. Criterion Validity of Spring CBMreading with Spring MCA-III in Reading: MN LEA 3 (Spring Data Collection)

Grade	N	CBMreading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	502	137.30 (44)	352.97 (22)	.74	131.5	.87	.80	.79
4	505	160.98 (48)	451.54 (18)	.74	161.5	.87	.78	.78
5	505	172.70 (41)	554.09 (15)	.70	164.5	.85	.76	.75
6	472	176.57 (41)	654.35 (19)	.64	173.5	.81	.72	.73
Some Risk (Partially Meets Standards)								
3	502	137.30 (44)	352.97 (22)	.74	--	.58	--	--
4	505	160.98 (48)	451.54 (18)	.74	165.5	.63	.70	.55
5	505	172.70 (41)	554.09 (15)	.70	172.5	.66	.69	.53
6	472	176.57 (41)	654.35 (19)	.64	184.5	.60	.69	.56
High Risk (Does Not Meet Standards)								
3	502	137.30 (44)	352.97 (22)	.74	121.5	.91	.82	.82
4	505	160.98 (48)	451.54 (18)	.74	144.5	.88	.78	.79
5	505	172.70 (41)	554.09 (15)	.70	151.5	.91	.83	.81
6	472	176.57 (41)	654.35 (19)	.64	165.5	.87	.77	.78

Table 42. Criterion Validity of Spring CBMreading with Spring Minnesota Comprehensive Assessment III (MCA-III) in Reading: MN LEA 2 (Spring Data Collection)

Grade	N	CBMreading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	252	142.95 (39)	353.34 (23)	.69**	142.5	.83	.76	.77
4	240	165.98 (39)	451.83 (16)	.69**	165.5	.82	.75	.75
5	234	175.33 (35)	558.69 (15)	.62**	167.5	.83	.73	.72
Some Risk (Partially Meets Standards)								
3	252	142.95 (39)	353.34 (23)	.69**	--	.58	--	--
4	240	165.98 (39)	451.83 (16)	.69**	--	.58	--	--
5	234	175.33 (35)	558.69 (15)	.62**	174.5	.66	.67	.54
High Risk (Does Not Meet Standards)								
3	252	142.95 (39)	353.34 (23)	.69**	127.5	.85	.73	.71
4	240	165.98 (39)	451.83 (16)	.69**	150.5	.90	.76	.84
5	234	175.33 (35)	558.69 (15)	.62**	151.5	.93	.93	.88

Table 43. Criterion Validity of Spring CBMreading on Spring MAP in Reading: WI LEA 1 (Spring Data Collection)

Grade	N	CBMreading M (SD)	MAP M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (≤ 40th percentile)								
2	33	76.88 (45)	181.61 (19)	.87**	66	.97	.91	.91
3	26	115.31 (54)	195.65 (17)	.89**	76	.99	.86	.95
4	31	132.55 (41)	208.23 (13)	.76**	123	.89	.86	.85
5	28	154.50 (33)	211.11 (13)	.66**	140	.89	.78	.79
6	25	155.76 (38)	215.08 (12)	.74**	149	1.00	1.00	.83
Some Risk (20th to 40th percentile)								
2	33	76.88 (45)	181.61 (19)	.87**	58	.68	.67	.74
3	26	115.31 (54)	195.65 (17)	.89**	108.5	.85	1.00	.82
4	31	132.55 (41)	208.23 (13)	.76**	123	.72	.75	.74
5	28	154.50 (33)	211.11 (13)	.66**	144	.69	.80	.60
6	25	155.76 (38)	215.08 (12)	.74**	149	.92	1.00	.71
High Risk (≤ 20th percentile)								
2	33	76.88 (45)	181.61 (19)	.87**	32	.99	.86	.96
3	26	115.31 (54)	195.65 (17)	.89**	62	1.00	1.00	.87
4	31	132.55 (41)	208.23 (13)	.76**	94	1.00	1.00	.93
5	28	154.50 (33)	211.11 (13)	.66**	127	.97	1.00	.92
6	25	155.76 (38)	215.08 (12)	.74**	140	.92	1.00	.77

Table 44. Criterion Validity of Spring CBMreading with Spring Massachusetts Comprehensive Assessment (MCA): MA LEA 1 (Spring Data Collection)

Grade	N	CBMreading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk ("Warning" and "Needs Improvement")								
3	93	138.82 (38)	241.89 (14)	.72**	132.5	.86	.79	.78
4	94	145.85 (38)	238.40 (15)	.71**	143.5	.81	.73	.78
5	72	158.99 (28)	243.63 (13)	.59**	157	.87	.74	.76
Some Risk ("Needs Improvement")								
3	93	138.82 (38)	241.89 (14)	.72**	132.5	.74	.72	.69
4	94	145.85 (38)	238.40 (15)	.71**	144.5	.69	.69	.64
5	72	158.99 (28)	243.63 (13)	.59**	155.5	.86	.73	.76
High Risk ("Warning")								
3	93	138.82 (38)	241.89 (14)	.72**	103.5	.96	1.00	.93
4	94	145.85 (38)	238.40 (15)	.71**	128	.89	.78	.78
5	72	158.99 (28)	243.63 (13)	.59**	137.5	.80	1.00	.79

Predictive Validity of the Slope

Validity of CBMreading passages were examined using the TOSREC, AIMSweb R-CBM, Measures of Academic Progress (MAP), and DIBELS Next. Table 45 depicts correlations between the slope and the achievement outcome. Coefficients provided in

Table 46 were derived from progress monitoring data. Students were monitored with grade level passages for AIMSweb and DIBELS Next. Correlation coefficients in

Table 46 may be underestimated due to differences in error (i.e., Standard Error of the Estimate and Standard Error of the Slope) between passage sets (see Ardoin & Christ, 2009 and Christ & Ardoin, 2009). The increased precision of CBMreading passages may lead to less variable slopes compared to more error prone progress monitoring passages. This in turn may deflate the measure of association between the two measures.

Table 45. Predictive Validity for the Slope of Improvement by CBMreading Passage Level

Passage Level	Test or Criterion	N	# CBMreading Data Points	Weeks of Monitoring	Coefficient
Level A	TOSREC Mid-Year	58			.43
Level B		98			.45
Level C		158			.36
Level A	TOSREC End of Year	58			.58
Level B		98			.22
Level C		158			.14
Level A	TOSREC*	85		1-24	.46
Level B		130		1-29	.56
Level C		186		1-29	.16

Level A	DIBELS Next	57	10-30	10-30	.89
Level B		197	10-30	10-30	.82
Level C		152	10-30	10-30	.60
Level A	AIMSWEB	33	10-30	30	.98
Level B		39	10-30	30	.84
Level C		70	10-30	30	.78
Level A	MAP	49	10	10	.21
Level B		71	10-20	10	.23
Level C		112	6-20	10	.21
Level A	MAP	33	14-30	30	.03
Level B		42	14-30	30	.41
Level C		78	18-30	30	.17

Note. Reported coefficients are partial Pearson correlation coefficients. Or rxy.z where x is the slope of improvement, y is the outcome measure and z is the intercept (initial level). TOSREC coefficients are based on a partial data set from students in Georgia and Minnesota.*

Table 46. Correlation Coefficients between CBMreading Slopes, AIMSweb R-CBM, and DIBELS Next

	AIMSweb Slope			DIBELS Next Slope		
Passage Level	N	Weeks of Monitoring (range)	Coefficient (95% CI)	N	Weeks of Monitoring (range)	Coefficient (95% CI)
A	Grade 1 (42) Grade 2 (15) Grade 3 (4) *Total N = 59*	10–30	.95 (.92 - .97)	Grade 1 (42) Grade 2 (27) Grade 3 (6) *Total N = 75*	10–30	.76 (.65 - .85)
B	Grade 1 (6) Grade 2 (41) Grade 3 (38) Grade 4 (15) Grade 5 (7) Grade 6 (1) *Total N = 108*	10–30	.85 (.79 - .90)	Grade 1 (6) Grade 2 (113) Grade 3 (91) Grade 4 (27) Grade 5 (14) Grade 6 (2) *Total N = 253*	10–30	.75 (.69 - .80)
C	Grade 4 (49) Grade 5 (44) Grade 6 (23) *Total N = 116*	10–30	.64 (.52 - .74)	Grade 4 (130) Grade 5 (112) Grade 6 (51) *Total N = 293*	10–30	.50 (.38 - .61)

Note. CI = Confidence Interval. Samples are disaggregated by grade level.

aReading

Content Validity

The development and design of aReading has a strong basis in reading research and theory. Items were created and revised by reading teachers and experts. See previous section on item writing processes. Extensive field testing has been conducted to establish appropriate items for aReading. For instance, the National Reading Panel (NRP; 2000a) submitted a report detailing the current knowledge base of reading, as well as information on effective approaches to teach children how to read and the important dimensions of reading to be emphasized. Factor analysis of preliminary data provided evidence for a large primary factor (i.e., unidimensionality) and several smaller factors, across the aReading items. Thus, aReading is designed to provide both a unified and a component assessment of these dimensions, specifically focusing on five main areas (as put forth by the NRP, 2000a): Concepts of Print, Phonological Awareness, Phonics, Vocabulary, and Comprehension.

The following describes the field testing process in order to derive item parameters to examine both difficulty and content areas that aReading items are addressing.

Common Core State Standards: Foundational Skills

Common Core Subgroups / Clusters	aReading Domains
Print Concepts	Concepts of Print
Phonological Awareness	Phonemic Awareness
Phonetic Awareness	Phonetic Awareness
Vocabulary	Vocabulary

Common Core State Standards: College and Career Readiness Reading Standards for Literature / Informational Text

Common Core Subgroups / Clusters	aReading Domains
Key Ideas and Details	Comprehension
Craft and structure	Comprehension & Vocabulary
Integration of Knowledge and Ideas	Comprehension & Vocabulary

aReading	Common Core State Standards & MN K–12 Standards
Concepts of Print:	RF K.1, RF 1.1
Familiarity with print/books	RI K.5, RF K.1a
Understands appropriate directionality and tracking in print	RF K.1a
Identifies organizational elements of text	RF K.1a,c,d; RF 1.1a, L 1.2b,c; L 2.2b,c, etc.; L 5.2a,b,c,d, RI K.6
Letter recognition	RF K.1b,d; L K.1a, L 1.1a
Word recognition	RF K.1b; RF K.1d
Sentence recognition	
Phonological Skills:	
Letter and word recognition / identification	L 3.2f

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Syllabication	RF K.2b; RF 1.3d
Letter and word recognition/identification	L.3.2f
Onset-rime	RF k.2a, c
Phonemic categorization	RF K.3d
Phonemic isolation	RF K.2b,c,d; RF 1.2a,c
Phonemic identification	RF 1.2b,d
Phonemic manipulation	RF K.2e
Skills Related to Phonics:	
Single consonant identification	RF K.2d; RF K.3a; RF 1.2c
Single vowel identification	RF K.2d; RF K.3b; RF 1.2a,c; RF 2.3a,c
Combined vowel identification	RF 1.3c; RF 2.3b
Consonant blends	RF 1.2b
Consonant digraphs	RF 1.3a; L K.2c
R-, L-, -gh controlled vowel identification	RF 1.2b
Vowel digraphs and diphthongs	RF 1.3c; RF 2.3b
Phonograms	
Recognize and analyze word roots and affixes	RF 3.3b; L 4.4b; L 5.4b
Spelling	RF 2.3c
Skills Related to Vocabulary:	
Single-meaning words	L K.4a,b
Double-meaning words	RF 1.3f; RF 2.3d; L K.4a,b
Compound words and contractions	L 2.4d
Base/root word identification and use	RF 3.3b; L K 4b; L1.4b,c; L 3.3a; L 3.4c; L 4.4b; L 5.4b
Word relationships	RL 3.4; RL 4.4; RL 5.4; L K.5a,b; L 1.5a,b; L 3.1a,c; L 3.4; L 2.5, 3.5, 4.5, etc.; L 4.4c; L 5.4a,c
Skills Related to Comprehension:	
Identify and locate information	RL K.1, 1.1, 2.1, etc.; RI K.1, 1.1, 2.1, etc.
Using inferential processes	RL K.7; 1.7, 2.7, etc.; RL K.9, RL 2.2, 2.3; RL 3.2, 3.3; RI K.7, 1.7, 2.7, etc.
Comprehension monitoring	RL K.4; RI K.4; RI 1.4
Awareness of text/story structure	RL k.5, 1.5, 2.5, etc.; RI 4.5, RI 5.5
Awareness of vocabulary use	RL 2.4
Evaluative and analytical processes	RL 2.6, 3.6, 4.6, etc.; RI 3.6

aReading literary passages include the following text types:

- Fiction / Literature
- Literary Nonfiction / Narrative Nonfiction
- Poetry

Informational text types include:

- Exposition

- Argumentation and persuasive text
- Procedural text and documents.

For Reading Comprehension items, both literary and informational text types were used.

For Vocabulary, Orthography and Morphology items, response types include:

- Selected Response
- Conventional Multiple Choice
- Alternate Choice
- Matching
- Multiple True-False

Targeted standards include:

- Identify common misspellings
- Recognize and analyze affixes and roots to determine word meaning in context;
- Use / recognize appropriate word change patterns that reflect change in meaning or parts of speech (e.g., derivational suffixes)
- Identify word meaning in context
- Demonstrate ability to use reference materials to pronounce words, clarify word meaning
- Understand figurative language in context
- Use word relations to improve understanding
- Distinguish similar-different word connotations and/or denotations

Test items were created based upon the following categories from the Common Core State Standards:

- Key Ideas and Details
- Craft and Structure
- Integration of Knowledge and Ideas

The test question types include the following:

- Locate / Recall: Identify textually explicit information and make simple inferences within and across texts
- Integrate / Interpret: Make complex inferences and/or integrate information within and across texts
- Critique / Evaluate: Consider text(s) or author critically

Pilot Test

In 2007, there were seven data collections across four districts, six schools, and 78 classrooms with 1,364 total students. Those data were used to estimate item parameters using student samples from Kindergarten through Third Grade. See Table 47 below.

Table 47. School Data Demographics for aReading Pilot Test

Category	School A	School B	School C	School D	School E	School F
White	94%	60%	10%	71%	3%	19%
Black	<1%	11%	64%	16%	83%	51%
Hispanic	<1%	<1%	21%	4%	2%	1%
Asian/Pacific Islander	5%	23%	3%	8%	12%	28%
American Indian/Alaska Native	<1%	<1%	2%	1%	<1%	<1%
Free/Reduced Lunch	13%	36%	89%	28%	96%	76%

Twelve to thirteen laptop computers were used in each data collection. The test was administered to students by class. Each student used a mouse to navigate the computer and headphones to hear the audio. Keyboards were covered so that students could not touch them, and each computer was surrounded by a foam board to discourage students from looking on other student's computer screens.

Data collections were proctored by two to three data collectors who entered each student's name and identifying information. Proctors attended to the children if they had questions, but did not provide help on any item. Tests consisted of 50–80 items across six domains of reading; 20 items, the linking items, were on each test and administered to all students in all sites. The linking items make it possible to import all items into a data super matrix, enabling each item parameter to be based directly and inferentially on data from all participants across all tests.

A summarization of the mean, standard deviation, minimum and maximum values for the three IRT parameters is presented in Table 48 for each reading domain. The number of items developed in each reading domain for the different ability levels are presented in Table 49. From over 500 items developed, 366 items were identified as being accurately developed and having residual values that were less than 1.68.

Table 48. Summarization of K–5 aReading Parameter Estimates by Domain

		Parameter (a)				Parameter (b)				Parameter (c)			
Domain	N	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max
Phonics	198	1.49	.16	1.06	2.01	.19	1.0	-2.13	2.65	.17	.04	.09	.35
Comprehension	24	1.44	.17	1.17	1.94	.77	.37	.14	1.37	.17	.04	.09	.24
Vocabulary	34	1.55	.27	1.15	2.50	.83	.99	-2.55	2.95	.16	.05	.09	.30
Concepts of Print	38	1.50	.19	1.18	2.20	-1.55	.75	-2.67	.64	.16	.02	.13	.22
Decoding & Fluency	65	1.57	.23	1.17	2.23	-.37	.68	-1.78	1.77	.18	.06	.11	.40
Phonemic Awareness	6	1.28	.15	1.03	1.43	-.41	1.03	-2.22	.45	.21	.04	.14	.28

Note. M = Mean.

A summary of item difficulty information is provided in Table 49. Analysis on level of difficulty after item parameterization for the five domains indicated that aReading items are representing domains as would be expected—with Concepts of Print being administered at the low end of ability and Comprehension at the high end.

Table 49. Item Difficulty Information for K-5 aReading Items

	Number of Items at Each Parameter b-Value of Difficulty						
Domain	(b≤-3)	(-3<b≤-2)	(-2<b≤-1)	(-1<b ≤0)	(0<b≤1)	(1<b≤2)	(2<b≤3)
Phonics	0	2	23	54	75	39	5
Comprehension	0	0	0	0	16	8	0
Vocabulary	0	1	0	3	17	10	3
Concepts of Print	0	10	17	10	1	0	0
Decoding & Fluency	0	0	7	44	11	3	0
Phonemic Awareness	0	1	1	1	3	0	0

Field Testing and Item Parameterization

To derive item parameters, data were collected in the fall and winter of 2009–10 at seven different schools in Minnesota, with similar methods used in pilot field testing data collection. Students in Kindergarten through Fifth Grade were drawn from seven schools in the suburbs near Minneapolis, Minnesota. As the goal was to test a large number of students (300 per item), project personnel wanted to ensure that the majority of students in schools would be able to participate without getting frustrated. Thus, English Language Learner (ELL) students would not be the best population to participate. School demographics are presented in Table 50 below. Sample sizes by school and grade are presented in Table 51 below.

Table 50. School Demographics for Field-Based Testing of aReading Items

Category	School A	School B	School C	School D	School E	School F	School G
White	89%	68%	78%	72%	69%	76%	63%
Black	3%	16%	7%	7%	5%	4%	5%
Hispanic	3%	8%	8%	7%	6%	4%	26%
Asian	4%	8%	7%	13%	19%	15%	6%
American Indian	1%	<1%	<1%	1%	1%	1%	<1%
Free/Reduced Lunch	21%	42%	37%	24%	14%	20%	41%
LEP	1%	12%	9%	14%	14%	15%	28%
Special Education	10%	8%	8%	11%	10%	11%	13%
Grades Served	K-6	K-5	K-5	K-5	K-5	K-5	K-5
Total School Population	470	663	396	782	766	690	638

Note. LEP=Limited English Proficient

Table 51. Sample Sizes for K-5 aReading Field-Testing by Grade and School

Grades	School A	School B	School C	School D	School E	School F	School G
K–1	100	203	128	243	278	216	215
2–3	130	238	123	255	258	180	174
4–5	150	212	114	243	238	180	182
Total	380	653	365	741	774	576	571

Field Testing to Establish Linking Items

IRT requires that each field-tested item be sampled on 300 individuals (Weiss personal communication, 2009). Therefore, our goal was to reach 300 students tested per item; some items were tested on more than 300 students. Sampling at this rate ensures that all three parameters (*a, b,* and *c*) are stable estimates (low levels of standard error).

The goal of the first data collection was to identify and establish parameters for linking items. Linking items ($N = 16$) are those items that were included on each subsequent field test as necessary to use a mixed-group common-item linking procedure (Kolan & Brennan, 2004). Without linking items, examinee responses across alternate items and examinees samples could not be compared and used to estimate item parameters. Linking items were developed and selected to represent all domains as well as the range of item difficulties, which generally correspond with reading performance from Kindergarten through Fifth Grade. Identification of linking items from the pilot data collection was extremely important because they appear on each subsequent field test. Project personnel identified 16 linking items that spanned across a range of difficulty levels and were content-balanced.

aReading personnel systematically chose 55 items out of the entire bank of items ($N = 638$). First, they individually chose what they determined were the best 55 items based on findings from previous administrations and on literacy research. The number of items chosen per domain was calculated based on the a priori model. For example, Concepts of Print and Phonological Awareness develop in Kindergarten and First Grade. Therefore, the proportion of these item types should be much smaller than the proportion of Comprehension items on tests; Comprehension develops across five grades, not just two. The number of items per grade level was similarly determined.

aReading staff decided that some items would be too difficult for young students at the first data collection in which 55 items were to be tested. Thus, the administration was structured to have five tests with branching and termination criteria. Each test was content-balanced and successive tests were sequenced so they became progressively more difficult (item difficulty was based on expert judgment of project personnel). For instance, the first test included 15 items that were considered to be the easiest. Based on performance within each test, students' administration was either terminated (due to the number of incorrect responses) after a test was completed and prior to subsequent tests, or continued to the next, progressively difficult, test (if enough correct responses were given). If an examinee's test terminated, then it was assumed that the examinee would not respond to subsequent items at a rate greater than chance.

The results of this initial field testing were used to guide the selection of linking items. These results were not included in the super matrix or to estimate the final item parameters.

Field Testing to Establish Item Parameters

Based on best estimates of the project team, items were sequenced by difficulty and divided into six sets of three progressively more difficult tests [e.g., for Schools A & B there was a fall set of three tests (K–1, 2–3, 4–5) and a spring set of three tests (K–1, 2–3, 4–5)]. While all reading domains were assessed at all grade levels, grade-level tests were constructed with the particular domain emphasis for that grade in mind. Specifically, personnel believed that Kindergarten and First Grade examinees should be assessed in the domains of Concepts of Print, Phonological Awareness, and some Phonics skills. Thus, it seemed reasonable to combine these grades and test them using the same set of items. Similarly, it was expected that examinees in grades two and three and grades four and five were similar in reading development. The most relevant domains for grades two and three seemed to be Phonics and Vocabulary. Finally, the focus for grades four and five was Vocabulary and Comprehension. It is important to note that each grade was tested on Vocabulary and Comprehension, but at varying levels of difficulty corresponding with grade level.

Excluding the first data collection at School A, both the Kindergarten to First Grade (K–1) tests and the second to Third Grade (2–3) tests had 39 new items on each. Thirty-one new items were on each fourth to Fifth Grade (4–5) test. The number of items on the grade 4–5 tests was reduced due to the majority of items belonging to the Comprehension domain. In general, Comprehension items require more time because more reading is involved. This means that the grades K–1 and 2–3 tests each had a total of 55 items, including the linking items, and the grades 4–5 test had a total of 47 items, including the linking items.

Procedure: Data Collection Overview

Data were collected using a mobile computer lab ($N = 28$ laptops each) or the school's computer lab. At the time of administration, data collectors directed students to the appropriate computer, located in a test carrel, and provided a brief set of directions. Visual stimuli are presented on a computer monitor and auditory stimuli are presented with padded earphones (padding helps isolate students from extraneous noises and helps ensure that the assessment could be conducted within a populated area). The students receive oral directions from a proctor or teacher followed by automated directions and on-screen demonstrations to guide them through the test. Students responded to items in sessions of 15–30 minutes. Upon completion, students were free to return to their classroom.

FALL 2009 DATA COLLECTIONS: OCTOBER

School A. The purpose of this initial data collection was to identify linking items (procedure described above). Three hundred sixty four students participated in this data collection. Once linking items were identified ($N = 16$), they were included in all subsequent tests for which items were field tested (with one exception; School B fall data collection, grades 4–5 test).

School B. As another early data collection in which aReading personnel had no data to aid in the selection of items, items considered to be high quality and representative of a range of ability levels

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and content for this data collection were selected. Five linking items were unintentionally left out of the grades 4–5 test. As a result, items from the grades 4–5 test were added to the Super matrix once all data collections were completed. The researchers adjusted the parameters appropriately. Five hundred and sixty total students participated in this data collection at this school; specifically, 153 students were administered the grade K–1 test, 211 students were administered the grades 2–3 test, and 196 students were administered the grades 4–5 test.

FALL 2009 DATA COLLECTIONS: NOVEMBER

School C. This elementary school served as a make-up school for items tested at School B. In other words, the goal of 300 students per item was not achieved at School B due to the student population. Students at School C took the same test set as those at School B in order to obtain the goal of 300 students per item. Three hundred and sixty two total students participated in this data collection at this school; specifically, 128 students were administered the grades K–1 test, 123 students were administered the grades 2–3 test, and 111 students were administered the grades 4–5 test.

School D. Items were chosen with consideration for difficulty level and content balance. Seven hundred and forty one total students participated in this data collection at this school; specifically, 243 students were administered the grades K–1 test, 255 students were administered the grades 2–3 test, and 243 students were administered the grades 4–5 test.

FALL 2009 DATA COLLECTIONS: DECEMBER

School E. Items were chosen with consideration for difficulty level and content balance. Seven hundred and twenty seven total students participated in this data collection at this school; specifically, 217 students were administered the grades K–1 test; 238 students were administered the grades 2–3 test; 272 students were administered the grades 4–5 test.

WINTER 2010 DATA COLLECTIONS: JANUARY

School A. Based on initial item analysis of the October data collection, more items that were very easy (< -2.0) and very difficult items (> +2.0) were needed to expand the range of linking items. As a result, project personnel focused on adding a majority of extremely easy items (in the domains of Concepts of Print and Phonological Awareness) to the grades K–1 test. The 4–5th grade test included high level Vocabulary items and Comprehension items considered very difficult due to length of passage, vocabulary, and question type. The tests at this school consisted of an entirely new item set. Three hundred and eighty total students participated in this data collection at this school; specifically, 100 students were administered the grades K–1 test, 130 students were administered the grades 2–3 test, and 150 students were administered the grades 4–5 test.

WINTER 2010 DATA COLLECTIONS: FEBRUARY

School C. Again, this school served as the make-up school for previous fall data collections (i.e., School B, School D, and School E). Three hundred and sixty two total students participated in this data collection at this school; specifically, 126 students were administered the grades K–1 test, 122 students were administered the grades 2–3 test, and 114 students were administered the grades 4–5 test.

School D. Items were chosen with consideration for difficulty level and content balance. Tests administered consisted of an entirely new item set. Seven hundred and ten total students participated in this data collection at this school; specifically, 234 students were administered the grades K–1 test, 252 students were administered the grades 2–3 test, and 224 students were administered the grades 4–5 test.

School G. Items were chosen with consideration for difficulty level and content balance. Five hundred and seventy one total students participated in this data collection at this school; specifically, 215 were administered the grades K–1 test, 174 students were administered the grades 2–3 test, and 182 students were administered the grades 4–5 test.

SPRING 2010 DATA COLLECTIONS: MARCH

School B. Items were chosen with consideration for difficulty level and content balance. Tests administered at School B were the same as those administered during the winter data collection at School F. Six hundred and fifty three total students participated in this data collection at this school; specifically, 203 students were administered the grades K–1 test, 238 students were administered the grades 2–3 test, and 212 students were administered the grades 4–5 test.

School E. School E served as the make-up school for all data collections in need of more administrations for items. Seven hundred and sixty eight total students participated in this data collection at this school; specifically, 278 students were administered the grades K–1 test, 258 students were administered the grades 2–3 test, and 232 students were administered the grades 4–5 test.

School F. Items were chosen with consideration for difficulty level and content balance. Tests administered consisted of an entirely new item set. Five hundred and seventy six total students participated in this data collection at this school; specifically, 216 students were administered the grades K–1 test, 180 students were administered the grades 2–3 test, and 180 students were administered the grades 4–5 test.

SPRING 2012 DATA COLLECTION

Analysis of the initial field parameterization indicated that the item bank provided the most information for students with ability levels in the middle range on the theta scale (mostly between -2.0 and 2.0). However, the bank lacked items for students' ability levels at the extreme ends of the theta scale. Because the test bank needs more information for students with extremely low ability levels (less than -2.0 on the theta scale) and those with extremely high ability levels (more than 2.0), the aReading team developed additional items that targeted Kindergarten through early First Grade level students and also late fifth through early Sixth Grade students. The new easy items focused on the Concept of Print domain. The new items created for the higher grade students were all Comprehension items that contained reading passages that reflect fifth through Sixth Grade reading content.

The participants were students from two public schools in South St. Paul, Minnesota. The schools provided a richly diverse group of students. The aReading team administered the Concept of Print items to 411 Kindergarten and First Grade students (*N* = 19 classrooms) and the Comprehension items to 391 fifth and Sixth Grade students (*N* = 18 classrooms).

The team collected data for the Concept of Print items in November and December 2011 and the Comprehension items in March 2012. A range of two to three group administrations were completed in a day (during school hours and with transitions and scheduling conflicts). Research assistants and other project personnel supervised the test administrations, ensuring student safety and the integrity of collecting the data. Data collectors provided oral directions to the students. Students also received automated directions and on-screen demonstrations before beginning the test. The students completed the items on a web-based browser using laptops provided by the team. Each administration lasted approximately 15 to 30 minutes for each student and all responses were automatically saved in a secure online database.

FALL 2012 AND SPRING 2013 DATA COLLECTION

Over 9,000 students from six middle and junior high schools and four high schools in the upper Midwest participated to test items generated for aReading grades 6–12 (N=70 unique classrooms). Trained project personnel administered the assessments. Each test included linking items and 20 unique aReading items targeted to grade level spans from 6–8, 9–12, and 11–12. Each item was given to approximately 300 students. Administration lasted 20 to 45 minutes per student. Criterion measures were collected from each school and used for additional analyses.

Parameterization

All items were parameterized within a 3-PL IRT framework via the computer program Xcalibre (Guyer & Thompson, 2012). Xcalibre allows for the use of a sparse data-matrix used with linking items (described above) deriving item parameters for every item, even if all students did not complete each item. Table 52 below shows descriptive statistics for item parameters for aReading. Item parameters are used to calculate the level of information for each item at a given ability estimate (discussed in the previous section). Based on a student's current ability estimate during a CAT, the aReading algorithm selects the item that is likely to provide the most information for that student.

Table 52. Descriptive Statistics of K–12 aReading Item Parameters

Domain	N	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max
Overall	1101	1.34	.40	.46	3.78	.11	1.02	-2.87	2.77	.24	.04	.06	.36
COP	98	1.5	.46	.63	2.82	-1.14	.96	-2.64	1.45	.21	.02	.11	.25
Comprehension	521	1.39	.4	.46	3.78	.39	.71	-1.28	2.77	.24	.04	.06	.36
Vocabulary	229	1.34	.37	.61	3.03	.33	1.13	-2.87	2.62	.22	.03	.06	.29
Phonics	128	1.38	.44	.52	2.73	-.34	1.09	-2.58	1.95	.21	.02	.13	.33
PA	66	1.11	.32	.61	1.9	-.61	.87	-2.56	1.24	.21	.01	.16	.23
OMF	57	1.31	.31	.76	2.27	.58	.72	-.76	2.63	.24	.06	.06	.29

Note. COP = Concepts of Print; PA = Phonological Awareness; OMF = orthography, morphology, and figurative language.

Criterion-Related Validity

Criterion-related validity of aReading tests was examined using the Gates MacGinitie Reading Tests-4th Edition (GMRT-4th; MacGinitie, MacGinitie, Maria, & Dreyer, 2000). The GMRT-4th is a norm-referenced, group administered measure of reading achievement distributed by Riverside Publishing Company. It is designed to provide guidance in planning instruction and intervention and is typically used as a diagnostic tool for general reading achievement. The GMRT-4th was normed with students in the pre-reading stages through high school levels. The GMRT-4th was selected because of its strong criterion validity. Correlations between the GMRT composite score and comprehension and vocabulary subtests of the Iowa Test of Basic Skills and GMRT composite scores across grades is high (.76 and .78 respectively; Morsy, Kieffer, & Snow, 2010). A similar pattern of results were observed between the GMRT and subscales of the California Tests of Basic Skills (.84 and .81 respectively; Morsy et al., 2010). GMRT scores also correlate highly with Comprehensive Tests of Basic Skills vocabulary, comprehension, and composite scores (.72, .79, and. 83 respectively; Morsy et al., 2010). Further, the correlation between GMRT composite scores and reading scores on the Basic Academic Skills Samples were strong as well (.79; Jenkins & Jewell, 1992).

The measure of interest with the GMRT-4th is the extended scale scores (ESS). The ESS puts the results from the test on a single continuous scale to allow comparison across time and grades. All materials were provided to students, including the test booklet and answer booklet.

Five trained aReading project team data collectors administered the GMRT-4th during February of 2011 at two separate schools. Participants included students in first through Fifth Grades. Three classrooms per grade at School A participated (n = 622); all students in first through Fifth Grades at School B participated (n = 760). The majority of students at Schools A and B were white (69%). Students were administered the word decoding/vocabulary and comprehension subtests of the GMRT-4th during two separate testing sessions. Some students were administered the word decoding/vocabulary section first while other students were administered the comprehension subtest first. See the Table 53 below for demographic information, disaggregated by school.

Table 53. Demographics for Criterion-Related Validity Sample for GMRT-4th and aReading

Category	School A	School B
White	70%	69%
Black	6%	5%
Hispanic	9%	6%
Asian/Pacific Islander	13%	19%
American Indian/Alaskan Native	3%	1%
Free/Reduced Lunch	19%	14%
LEP	14%	14%
Special Education	11%	10%

Note. LEP = Limited English Proficiency. Percentages are rounded to whole numbers and therefore may not add to precisely 100.

Descriptive information for the GMRT-4th and correlation coefficients between each scale and aReading scores are provided in Table 63.

Table 54. Sample-Related Information for aReading Criterion-Related Validity Data

	Decoding			Vocabulary			Comprehension			Composite		
Grade	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
1	348	436	47	-	-	-	130	407	44	125	409	43
2	163	449	43	-	-	-	215	459	49	-	-	-
3	-	-	-	170	485	41	168	484	42	165	484	40
4	-	-	-	182	504	39	180	503	42	175	502	36
5	-	-	-	182	513	31	187	518	35	181	514	30
1—5	511	442.5	45	534	501	39	881	477	56	646	483	53

Note. M = Mean; SD = Standard Deviation

Table 55. Correlation Coefficients between GMRT-4th and aReading Scaled Score

Grade	Decoding	Vocabulary	Comprehension	Composite
1	.82 (131)	-	.73 (130)	.83 (125)
2	.68 (163)	-	.75 (215)	-
3	-	.79 (170)	.81 (168)	.84 (165)
4	-	.76 (182)	.72 (180)	.78 (175)
5	-	.65 (182)	.58 (187)	.64 (181)
1—5	.75 (348)	.74 (534)	.82 (881)	.86 (646)

Note. Sample size is denoted by ().

Overall, there appears to be a strong positive correlation between composite scores from the GMRT-4th and aReading scaled scores. There is some variability between grades, with coefficient values between .64 and .83. Subtests showed greater variability. Specifically, comprehension correlation coefficients ranged from .58 to .81.

Content, construct, and predictive validity of aReading is summarized in.

Table 56.

Table 56. Content, Construct, and Predictive Validity of aReading

Type of Validity	Grade	Test or Criterion	N (range)	Coefficient (if applicable) Range	Median
Content	K–5	Reading teachers/experts			
Content	K–3	Items administered by Theta Level	287		
Predictive	1–5	Gates-MacGinitie	125–215	0.64–0.84	0.78
	1		125	0.83	
	2*		215	0.75	
	3		165	0.84	
	4		175	0.78	
	5		181	0.64	
Construct	1–5	Curriculum-Based Measurement of Oral Reading Fluency	55–171	0.56–0.83	0.80
	1		55	0.83	
	2		171	0.81	
	3		108	0.74	
	4		114	0.80	
	5		103	0.56	
Construct	1-5	MAP	55–398	0.69–0.83	0.77
	1		55	0.69	
	2		302	0.83	
	3		391	0.83	
	4		398	0.77	
	5		376	0.73	

Note. Grade 2 Predictive validity for the GMRT-4th is based on the Comprehension subtest, whereas all other grades are based on the overall composite score.

More recently, data collections have produced aReading criterion-related evidence with various other criterion measures.

Table 57. Criterion Validity of Spring aReading with Spring Minnesota Comprehensive Assessment III (MCA-III) in Reading: MN LEA 1 (Spring Data Collection)

Grade	N	aReading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
6	202	522.01 (15.45)	651.36 (15.07)	.72**	521.5	.86	.78	.77
7	126	522.81 (14.95)	742.01 (15.26)	.66**	528.5	.83	.77	.76
8	94	524.95 (14.11)	843.22 (11.88)	.58**	534.5	.85	.81	.79
High Risk (Does Not Meet Standards)								
6	202	522.01 (15.45)	651.36 (15.07)	.72**	515.5	.83	.74	.74
7	126	522.81 (14.95)	742.01 (15.26)	.66**	523	.82	.75	.77
8	94	524.95 (14.11)	843.22 (11.88)	.58**	524.5	.84	.78	.78

Table 58. Criterion Validity for Spring aReading with Spring MCA-III in Reading: MN LEA 4 (Spring Data Collection)

Grade	N	aReading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	629	534 (27)	347 (21)	.82	532.5	.90	.83	.82
4	615	549 (28)	447 (16)	.81	550.5	.89	.82	.82
5	516	564 (32)	553 (16)	.84	556.5	.93	.84	.84
High Risk (Does Not Meet Standards)								
3	629	534 (27)	347 (21)	.82	524.5	.90	.82	.81
4	615	549 (28)	447 (16)	.81	536.5	.92	.84	.84
5	516	564 (32)	553 (16)	.84	544.5	.96	.89	.86

Table 59. Criterion Validity for Spring aReading with Spring MCA-III in Reading: MN LEA 3 (Spring Data Collection)

Grade	N	aReading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	156	504.97 (18.09)	351.56 (19.77)	.82	502.5	.89	.80	.79
4	63	508.17 (20.75)	447.33 (16.11)	.78	509.5	.86	.78	.74
5	148	528.02 (19.58)	557.91 (14.22)	.82	523.5	.91	.84	.83
6	152	529.18 (20.93)	655.09 (18.11)	.76	530.5	.86	.80	.78
Some Risk (Partially Meets Standards)								
3	156	504.97 (18.09)	351.56 (19.77)	.82	--	.59	--	--
4	63	508.17 (20.75)	447.33 (16.11)	.78	--	.46	--	--
5	148	528.02 (19.58)	557.91 (14.22)	.82	522.5	.80	.75	.75
6	152	529.18 (20.93)	655.09 (18.11)	.76	530.5	.64	.68	.63
High Risk (Does Not Meet Standards)								
3	156	504.97 (18.09)	351.56 (19.77)	.82	498.5	.92	.83	.82
4	63	508.17 (20.75)	447.33 (16.11)	.78	503.00	.95	.90	.85
5	148	528.02 (19.58)	557.91 (14.22)	.82	510.5	.96	.85	.87
6	152	529.18 (20.93)	655.09 (18.11)	.76	518.5	.95	.84	.87

Criterion-related validity evidence for aReading is not limited to the Midwest. See tables below.

Table 60. Criterion Validity of Spring aReading with Spring CRCT in Reading: GA LEA 1 (Spring to Spring Prediction)

Grade	N	aReading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	327	501.56 (20)	848.62 (28)	.75*	501.50	.84	.78	.78
4	314	513.53 (20)	848.30 (27)	.77*	514.50	.86	.79	.79

5	347	519.34 (19)	841.27 (25)	.74*	525.50	.83	.79	.78
High Risk (Does Not Meet Standards)								
3	327	501.56 (20)	848.62 (28)	.75*	478.50	.95	.91	.85
4	314	513.53 (20)	848.30 (27)	.77*	493.00	.93	.83	.84
5	347	519.34 (19)	841.27 (25)	.74*	502.50	.90	.85	.84

Table 61.Criterion Validity of Spring aReading with Spring Massachusetts Comprehensive Assessment (MCA): MA LEA 1 (Spring Data Collection)

Grade	N	aReading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (“Warning” and “Needs Improvement”)								
3	93	508.96 (22.16)	241.89 (14.08)	.81**	503.5	.89	.76	.77
4	93	512.17 (19.09)	238.40 (19.09)	.78**	513.5	.88	.75	.75
5	74	524.04 (15.41)	243.63 (13.20)	.64**	523.5	.85	.76	.76
Some Risk (“Needs Improvement”)								
3	93	508.96 (22.16)	241.89 (14.08)	.81**	504.5	.77	.76	.78
4	93	512.17 (19.09)	238.40 (19.09)	.78**	515	.73	.71	.63
5	74	524.04 (15.41)	243.63 (13.20)	.64**	522.5	.83	.75	.76
High Risk (“Warning”)								
3	93	508.96 (22.16)	241.89 (14.08)	.81**	483.00	.97	.88	.92
4	93	512.17 (19.09)	238.40 (19.09)	.78**	496.5	.95	.89	.85
5	74	524.04 (15.41)	243.63 (13.20)	.64**	511.5	.84	1.00	.78

Chapter 2.7: Diagnostic Accuracy

earlyReading

earlyReading diagnostic accuracy information was derived from the sample described in Table 31. earlyReading diagnostic accuracy information is provided for both Kindergarten and First Grade, using the Group Reading Assessment Diagnostic Evaluation (GRADE™) as a criterion measure. Measures of diagnostic accuracy were used to determine decision thresholds using criteria related to sensitivity, specificity, and area under the curve (AUC). Specifically, specificity and sensitivity were computed at different cut scores in relation to maximum AUC values. Decisions for final benchmark percentiles were generated based on maximizing each criterion at each cut score (i.e., when the cut score maximized specificity ≥ .70, and sensitivity was also ≥ .70; see Silberglitt & Hintze, 2005). In the scenario for which a value of .70 could not be achieved for either specificity or sensitivity, precedence was given to maximizing specificity.

Table 62. Kindergarten Diagnostic Accuracy for earlyReading Measures

	15th Percentile					40th Percentile				
	AUC	Cutpoint	Sens	Spec.	Classification	AUC	Cutpoint	Sens	Spec.	Classification
Concepts of Print										
F to F1	.86	7	.80	.82	.82	.80	9	.74	.69	.72
F to S	.82	7	.76	.71	.71	.74	8	.75	.65	.68
Onset Sounds										
F to F1	.94	8	.80	.81	.81	.79	12	.74	.69	.72
F to S	.88	7	.82	.89	.89	.74	12	.80	.77	.78
W to S	.76	14	.69	.86	.85	.73	15	.62	.78	.74
Letter Names										
F to F1	.73	22	.60	.59	.59	.65	25	.60	.64	.62
F to S	.81	20	.76	.74	.74	.76	25	.69	.69	.69
W to S	.79	35	.72	.73	.73	.77	40	.73	.73	.73
S to S	.78	48	.71	.70	.70	.76	51	.71	.72	.72
Letter Sounds										
F to F1	.95	1	.86	.14	.87	.68	7	.63	.60	.61
F to S	.81	6	.76	.78	.78	.75	10	.67	.71	.70
W to S	.85	22	.78	.75	.75	.82	28	.75	.73	.74
S to S	.85	34	.82	.80	.80	.71	42	.73	.59	.63
Rhyming										
F to F1	.89	5	.80	.80	.80	.77	9	.72	.69	.71
F to S	.80	6	.76	.75	.75	.81	8	.79	.72	.74
W to S	.92	7	.88	.89	.89	.83	12	.75	.76	.76
S to S	.86	14	.88	.75	.76	.76	15	.71	.69	.70
Word Blending										
F to S	.70	1	.88	.53	.56	.69	1	.77	.60	.65
W to S	.82	4	.82	.80	.80	.74	8	.73	.55	.60
S to S	.85	9	.88	.72	.73	.75	9	.64	.79	.75
Word Segmenting										
W to S	.85	4	.82	.81	.81	.78	15	.75	.76	.76
S to S	.90	28	.94	.87	.87	.76	32	.72	.57	.61
Sight Words 50										
S to S	.82	25	.78	.72	.72	.74	39	.71	.65	.66
Decodable Words										
S to S	.90	3	.78	.87	.86	.77	9	.72	.68	.69
Nonsense Words										
W to S	.86	3	.83	.79	.79	.76	5	.70	.72	.72
S to S	.90	6	.83	.81	.81	.78	8	.70	.79	.76
Composite										
F to F1	.96	28	.80	.91	.91	.79	42	.74	.67	.71
F to S	.91	33	.88	.84	.84	.84	40	.80	.77	.78
W to S	.91	40	.94	.72	.77	.85	47	.84	.72	.75
S to S	.95	52	.75	.74	.74	.81	60	.75	.74	.74

Note. F = Fall; W = Winter; S = Spring; [1]Base rates below the 15th percentile were low and above the 40th percentile were high. Note. Fall to Fall was concurrent and used the GRADE Level P as the criterion. All others used the GRADE Level K.

Based on these analyses, the values at the 40th and 15th percentiles were identified as the primary and secondary benchmarks for earlyReading, respectively. These values thus correspond with a prediction of performance at the 40th and 15th percentiles on the GRADE, a nationally normed reading assessment of early reading skills. Performance above the primary benchmark indicates the student is at low risk for long-term reading difficulties. Performance between the primary and secondary benchmarks indicates the student is at some risk for long-term reading difficulties. Performance below the secondary benchmark indicates the student is at high risk for long-term reading difficulties. These risk levels help teachers accurately monitor student progress using the FAST™ earlyReading measures. See

Table 62 below for Diagnostic Accuracy results using the GRADE as the criterion measure.

Table 63. First Grade Diagnostic Accuracy for earlyReading Measures

	15th Percentile					40th Percentile				
	AUC	Cutpoint	Sens.	Spec.	Classification	AUC	Cutpoint	Sens.	Spec.	Classification
Word Blending										
F to S	.87	6	.86	.80	.80	.82	7	.72	.72	.72
W to S	.82	8	.60	.80	.79	.78	8	.56	.84	.80
S1 to S2	.68	9	.55	.67	.66	.65	9	.50	.69	.66
Word Segmenting										
F to S	.78	25	.71	.72	.72	.75	27	.72	.68	.68
W to S	.82	29	.70	.74	.74	.79	30	.67	.67	.67
S1 to S2	.71	30	.64	.71	.70	.67	30	.53	.74	.70
Sight Words 150										
F to S	.97	5	.86	.92	.92	.91	14	.84	.81	.82
W to S	.97	21	.90	.95	.94	.95	44	.85	.89	.88
S1 to S2	.97	48	.91	.96	.96	.95	61	.87	.92	.91
Decodable Words										
F to S	.90	2	.86	.85	.85	.88	5	.76	.74	.75
W to S	.93	10	.80	.91	.91	.95	15	.85	.86	.86
S1 to S2	.93	22	.82	.82	.82	.96	24	.84	.89	.88
Nonsense Words										
F to S	.93	2	.86	.88	.88	.84	5	.76	.79	.79
W to S	.88	12	.80	.75	.75	.92	14	.93	.78	.81
S1 to S2	.87	14	.89	.80	.81	.87	17	.81	.77	.78
Sentence Reading/CBMR1										
F to S	.97	10	.86	.93	.93	.93	18	.84	.84	.84
W to S	.98	192	1.0	.95	.95	.98	372	.96	.91	.92
S1 to S2	.98	362	.82	.98	.97	.98	652	.94	.93	.93
Composite										
F to S	.98	25	1.0	.93	.93	.93	28	.76	.84	.83
W to S	.98	34	1.0	.82	.83	.97	37	1.0	.77	.81

S1 to S2	.99	45	.89	.90	.90	.97	51	.92	.92	.92

Note. F = Fall; W = Winter; S = Spring; [1] Sentence Reading was administered in the fall, CBMR was administered in the winter and spring. [2] Scores shown are equated.

More recently, diagnostic accuracy analyses have also been conducted using earlyReading subtest scores and composite scores to predict aReading. These findings are summarized in the tables below. Students were recruited from several school districts in Minnesota. Cut score was selected by optimizing sensitivity at about .70 and balancing sensitivity with specificity (Silberglitt & Hintze, 2005). In the tables that follow, dashes indicate unacceptable sensitivity and specificity due to low AUC.

Table 64. Diagnostic Accuracy of Fall earlyReading Concepts of Print Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Concepts of Print M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	5173	8.31 (2.63)	430.28 (27.43)	.58**	6.5	.80	.77	.71
Some Risk (20th to 40th percentile)								
KG	5173	8.31 (2.63)	430.28 (27.43)	.58**	6.5	.81	.74	.75
High Risk (< 20th percentile)								
KG	5173	8.31 (2.63)	430.28 (27.43)	.58**	6.5	.81	.79	.70

Table 65. Diagnostic Accuracy of Fall earlyReading Onset Sounds Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Onset Sounds M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	13203	11.59 (4.28)	430.28 (27.43)	63**	8.50	.84	.79	.77
Some Risk (20th to 40th percentile)								
KG	13203	11.59 (4.28)	430.28 (27.43)	.63**	8.50	.84	.79	.77
High Risk (< 20th percentile)								
KG	13203	11.59 (4.28)	430.28 (27.43)	.63**	7.5	.83	.79	.77

Table 66. Diagnostic Accuracy of Fall earlyReading Letter Names Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Letter Names M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	5173	27.29 (22.38)	430.28 (27.43)	.69**	11.50	.78	.71	.70
Some Risk (20th to 40th percentile)								
KG	5173	27.29 (22.38)	430.28 (27.43)	.69**	14.5	.79	.74	.73
High Risk (< 20th percentile)								
KG	5173	27.29 (22.38)	430.28 (27.43)	.69**	9.5	.82	.73	.73

Table 67. Diagnostic Accuracy of Fall earlyReading Letter Sounds Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Letter Sounds M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	5173	11.57 (11.76)	430.28 (27.43)	.62**	2.5	.80	.71	.73
1	842	34.83 (14.89)	466.04 (27.16)	.65	30.5	.73	.66	.65
Some Risk (20th to 40th percentile)								
KG	5173	11.57 (11.76)	430.28 (27.43)	.62**	3.5	.77	.72	.67
High Risk (< 20th percentile)								
KG	5173	11.57 (11.76)	430.28 (27.43)	.62**	1.5	.82	.79	.78
1	842	34.83 (14.89)	466.04 (27.16)	.65	17.5	.99	1.00	.89

Table 68. Diagnostic Accuracy of Fall earlyReading Letter Sounds Subtest with Spring aReading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	Letter Sounds M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	842	34.83 (14.89)	457.39 (25.21)	.31**	29.50	.75	.70	.69
High Risk (< 20th percentile)								
1	842	34.83 (14.89)	457.39 (25.21)	.31**	27.50	.78	.74	.71

Table 69. Diagnostic Accuracy of Winter earlyReading Letter Sounds Subtest with Spring aReading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	Letter Sounds M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	208	43.62 (18.25)	457.39 (25.21)	.58**	40.50	.77	.70	.72
High Risk (< 20th percentile)								
1	208	43.62 (18.25)	457.39 (25.21)	.58**	40.50	.76	.73	.70

Table 70. Diagnostic Accuracy of Winter earlyReading Rhyming Subtest with Spring aReading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	Rhyming M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	106	13.28 (3.34)	457.39 (25.21)	.53**	14.50	.75	.70	.70
High Risk (< 20th percentile)								
1	106	13.28 (3.34)	457.39 (25.21)	.53**	14.50	.71	.70	.64

Table 71. Diagnostic Accuracy of Fall earlyReading Word Segmenting Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Word Segmenting M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	-	-	-	-	-	-	-	-
High Risk (< 20th percentile)								
1	9843	26.20 (7.41)	466.04 (27.16)	.51**	22.50	.87	.78	.78

Table 72. Diagnostic Accuracy of Fall earlyReading Nonsense Words Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Nonsense Words M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	7997	13.14 (22.13)	466.04 (27.16)	.62**	9.50	.66	.60	.61
High Risk (< 20th percentile)								
1	7997	13.14 (22.13)	466.04 (27.16)	.62**	5.50	.89	.83	.78

Table 73. Diagnostic Accuracy of Fall earlyReading Sight Words Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Sight Words M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	9685	32.76 (33.40)	466.04 (27.16)	.67**	26.50	.69	.71	.58
High Risk (< 20th percentile)								
1	9685	32.76 (33.40)	466.04 (27.16)	.67**	4.5	.92	.85	.87

Table 74. Diagnostic Accuracy of Fall earlyReading Sentence Reading Subtest with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Sentence Reading M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	9618	34.23 (37.43)	466.04 (27.16)	.70**	19.5	.71	.70	.60
High Risk (< 20th percentile)								
1	9618	34.23 (37.43)	466.04 (27.16)	.70**	6.5	.94	.90	.87

Table 75. Diagnostic Accuracy of Fall earlyReading Sentence Reading Subtest with Spring aReading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	Sentence Reading M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	-	-	-	-	-	-	-	-
High Risk (< 20th percentile)								
1	9618	34.23 (37.43)	457.39 (25.21)	.66**	15.50	.72	.68	.66

Table 76. Diagnostic Accuracy of Winter earlyReading Sentence Reading Subtest with Spring aReading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	Sentence Reading M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
1	433	57.36 (36.69)	457.39 (25.21)	.78**	32.50	.82	.76	.76
High Risk (< 20th percentile)								
1	433	57.36 (36.69)	457.39 (25.21)	.78**	22.50	.92	.85	.85

Table 77. Diagnostic Accuracy of Winter earlyReading Composite with Winter aReading: MN LEA 3 (Fall to Winter Prediction)

Grade	N	Composite M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	577	34.45 (12.86)	430.95 (27.353)	.70**	27.5	.84	.77	.78
1	589	30.44 (9.99)	466.74 (27.05)	.73**	24.5	.85	.85	.73
Some Risk (20th to 40th percentile)								
KG	577	34.45 (12.86)	430.95 (27.353)	.70**	28.5	.79	.72	.70
1	590	30.44 (9.99)	466.74 (27.05)	.73**	24.5	.73	.75	.66
High Risk (< 20th percentile)								
KG	577	34.45 (12.86)	430.95 (27.353)	.70**	25.5	.82	.79	.76
1	590	30.44 (9.99)	466.74 (27.05)	.73**	23.5	.89	.86	.77

Table 78. Diagnostic Accuracy of Fall earlyReading Composite with Spring aReading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	Composite M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	577	34.45 (12.86)	415.34 (27.16)	.64**	37.50	.73	.68	.70
High Risk (< 20th percentile)								
KG	577	34.45 (12.86)	415.34 (27.16)	.64**	34.50	.76	.71	.70

Table 79. Diagnostic Accuracy of Winter earlyReading Composite with Spring aReading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	Composite M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (< 40th percentile)								
KG	479	42.92 (15.6)	415.34 (27.16)	.74**	49.50	.84	.76	.76
High Risk (< 20th percentile)								
KG	479	42.92 (15.6)	415.34 (27.16)	.74**	43.50	.84	.73	.77

Table 80. Diagnostic Accuracy of Fall earlyReading Composite (2014–15 Weights) with Spring aReading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	Composite M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (<40th percentile)								
KG	514	35.03 (6.28)	415.64 (27.24)	.69**	35.5	.75	.69	.70
1	170	40.23 (10.78)	459.89 (26.03)	.81**	34.5	.65	.63	.60
High Risk (<20th percentile)								
KG	514	35.03 (6.28)	415.64 (27.24)	.69**	34.5	.78	.74	.70
1	170	40.23 (10.78)	459.89 (26.03)	.81**	34.5	.70	.69	.60

Table 81. Diagnostic Accuracy of Winter earlyReading Composite (2014-15 Weights) with Spring aReading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	Composite M (SD)	aReading M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (<40th percentile)								
KG	522	48.02 (9.91)	415.34 (27.18)	.75	51.5	.85	.79	.75
1	171	49.77 (13.87)	459.25 (27.28)	.77	--	.65	--	--
High Risk (<20th percentile)								
KG	522	48.02 (9.91)	415.34 (27.18)	.75	48.5	.86	.79	.77
1	171	49.77 (13.87)	459.25 (27.28)	.77	43.5	.71	.71	.62

CBMreading

CBMreading diagnostic accuracy information is provided for first through Sixth Grades, using the TOSREC, and MAP as the criterion measures. Measures of diagnostic accuracy were used to determine decision thresholds using criteria related to sensitivity, specificity, and area under the curve (AUC). Specifically, specificity and sensitivity were computed at different cut scores in relation to maximum AUC values. Decisions for final benchmark percentiles were generated based on maximizing each criterion at each cut score (i.e., when the cut score maximized specificity ≥ .70, and sensitivity was also ≥ .70; see Silberglitt & Hintze, 2005). In the scenario for which a value of .70 could not be achieved for either specificity or sensitivity, precedence was given to maximizing specificity.

CBMreading diagnostic accuracy was determined based on a sample of 1,153 students in the state of Minnesota, spanning across three regions. Data was collected during the 2012–13 school year. The sample consisted of approximately 45% males and 55% females. Approximately 20% of the students involved were eligible for free and reduced lunch. The majority of students were White (52%). The remainder of the sample consisted of approximately 30% Hispanic, 12% Black, 4% Asian or Pacific Islander, and 1% American Indian or Alaska Native. Approximately 15% of students were receiving special education services. All participants were proficient in English. See Table 82 on the following page for diagnostic accuracy results.

Table 82. Diagnostic Accuracy by Grade Level for CBMreading Passages

Grade Level	N	Cut[a]	AUC	Sens.	Spec.	Classif.	Lag Time	Criterion Measure
20th Percentile								
1	171	16.5	0.81	0.75	0.63	0.71	2 to 4	TOSREC
2	206	42.5	0.93	0.88	0.87	0.88	2 to 4	
3	188	75.5	0.89	0.84	0.83	0.84	2 to 4	
4	181	108.5	0.87	0.78	0.82	0.79	2 to 4	
5	202	107.5	0.90	0.84	0.79	0.83	2 to 4	
6	205	118.5	0.90	0.92	0.72	0.88	2 to 4	
1	171	17	0.77	0.63	0.82	0.74	4 months	MAP
2	206	57	0.82	0.63	0.85	0.76	4 mo.	
3	188	88	0.8	0.77	0.75	0.76	4 mo.	
4	181	113	0.88	0.82	0.81	0.81	4 mo.	
5	202	101	0.89	0.7	0.91	0.86	4 mo.	
6	205	126	0.89	0.83	0.82	0.82	4 mo.	
1	171	21	0.79	0.78	0.7	0.73	8 mo.	
2	206	63	0.82	0.83	0.68	0.72	8 mo.	
3	188	67	0.77	0.51	0.88	0.75	8 mo.	
4	181	104	0.89	0.8	0.86	0.84	8 mo.	
5	202	97	0.89	0.74	0.92	0.88	8 mo.	
6	205	126	0.89	0.85	0.82	0.83	8 mo.	
1	171	16	0.8	0.66	0.81	0.76	~1 year	
2	206	82	0.9	0.87	0.84	0.86	~1 year	
3	188	88	0.89	0.82	0.81	0.82	~1 year	
4	181	114	0.87	0.83	0.76	0.78	~1 year	
5	202	108	0.89	0.8	0.85	0.84	~1 year	
6	205	126	0.85	0.77	0.79	0.79	~1 year	
30th Percentile								
1	171	16.5	0.81	0.75	0.63	0.71	2 to 4	TOSREC
2	206	44.5	0.94	0.91	0.83	0.89	2 to 4	
3	188	79.5	0.88	0.83	0.83	0.83	2 to 4	
4	181	117.5	0.83	0.73	0.79	0.75	2 to 4	
5	202	115.5	0.87	0.79	0.77	0.79	2 to 4	
6	205	135.5	0.88	0.76	0.82	0.78	2 to 4	
1	171	31	0.78	0.84	0.57	0.74	4 mo.	MAP
2	206	82	0.83	0.81	0.73	0.78	4 mo.	
3	188	85	0.77	0.57	0.86	0.66	4 mo.	
4	181	128	0.82	0.84	0.59	0.74	4 mo.	
5	202	125	0.82	0.65	0.75	0.69	4 mo.	
6	205	144	0.82	0.76	0.75	0.75	4 mo.	
1	171	24	0.78	0.74	0.7	0.73	8 mo.	
2	206	82	0.78	0.77	0.54	0.67	8 mo.	
3	188	98	0.8	0.82	0.65	0.76	8 mo.	
4	181	125	0.84	0.66	0.85	0.75	8 mo.	
5	202	128	0.86	0.8	0.73	0.76	8 mo.	
6	205	144	0.79	0.74	0.7	0.71	8 mo.	
1	171	22	0.83	0.76	0.77	0.76	~1 year	

2	206	82	0.91	0.72	0.89	0.76	~1 year
3	188	104	0.85	0.63	0.92	0.71	~1 year
4	181	122	0.85	0.7	0.86	0.78	~1 year
5	202	135	0.82	0.77	0.68	0.73	~1 year
6	205	144	0.8	0.76	0.75	0.75	~1 year

Note.[a]*Cut score was selected by optimizing sensitivity and then balancing it with specificity using methods presented by Silberglitt and Hintze (2005)*

Further diagnostic accuracy analyses were conducted using the Minnesota Comprehensive Assessment III. Students were administered the Minnesota Comprehensive Assessment III (MCA-III) in Reading in grades 3, 4, and 5. The MCAs are state tests that help school districts measure student progress toward Minnesota's academic standards and meet the requirements of the Elementary and Secondary Education Act (ESEA). Additionally, students completed three FastBridge Learning CBMreading probes during the spring. The median score was computed. Only those students providing complete data were utilized in the diagnostic accuracy analyses. More specifically, students with incomplete data regarding CBM-R Words Read Correctly (WRC) per minute, or those students with incomplete MCA-III Achievement Level Scores were excluded from analyses. ROC Analysis was used to determine diagnostic accuracy of FastBridge Learning CBMreading probes with Spring MCA-III scale scores serving as the criterion measure. Students were disaggregated by grade level. Diagnostic accuracy was computed for students identified as being at "High Risk" and those identified as "Somewhat at Risk" for reading difficulties using MCA-III Achievement Level Criteria (See Table 83). Data collection is ongoing.

Table 83. Diagnostic Accuracy for CBMreading and MCA III

Grade	N	CBM-R M (SD)	MCA-III M (SD)	r(x,y)	Cut[a]	AUC	Sensitivity	Specificity
High Risk (Does Not Meet Standards)								
K	--	--	NA	--	--	--	--	--
1	--	--	NA	--	--	--	--	--
2	--	--	NA	--	--	--	--	--
3	852	139 (40)	348 (20)	.76	131.5	.88	.80	.79
4	818	165 (39)	447 (15)	.71	153.5	.87	.80	.78
5	771	165 (40)	552 (16)	.70	151.5	.89	.80	.79
6 to 12	--	--	Pending		--	--	--	--
Somewhat High Risk (Does Not Meet or Partially Meets Standards)								
K	--	--	NA	--	--	--	--	--
1	--	--	NA	--	--	--	--	--
2	--	--	NA	--	--	--	--	--
3	852	139 (40)	348 (20)	.76	141.5	.86	.78	.76
4	818	165 (39)	447 (15)	.71	164.5	.83	.75	.71
5	771	165 (40)	552 (16)	.70	163.5	.84	.77	.76
6 to 12	--	--	Pending		--	--	--	--

Note. M = Mean. SD = Standard Deviation. [a]*Cut score was selected to balance sensitivity and specificity using methods modified from Silberglitt and Hintze (2005)*

Additional diagnostic accuracy analyses for various grade levels across multiple states is summarized in the tables on the following page.

Table 84. Diagnostic Accuracy on Fall CBMreading with Spring CRCT in Reading: GA LEA 1 (Fall to Spring Prediction)

Grade	N	CBMreading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	329	115.96 (42)	848.65 (28)	.66*	116.50	.79	.72	.71
4	320	137.64 (41)	848.18 (27)	.65*	130.50	.81	.72	.73
5	353	149.27 (40)	841.22 (25)	.57*	150.50	.71	.66	.66
High Risk (Does Not Meet Standards)								
3	329	115.96 (42)	848.65 (28)	.66*	80.50	.89	.82	.83
4	320	137.64 (41)	848.18 (27)	.65*	100.50	.85	.83	.85
5	353	149.27 (40)	841.22 (25)	.57*	128.50	.82	.79	.71

Table 85. Diagnostic Accuracy on Winter CBMreading on Spring CRCT in Reading: GA LEA 1 (Winter to Spring Prediction)

Grade	N	CBMreading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	327	117.22 (43)	848.64 (28)	.64*	119.50	.76	.69	.69
4	318	136.52 (41)	848.33 (27)	.61*	133.50	.78	.70	.71
5	350	149.75 (40)	841.14 (25)	.57*	152.50	.71	.65	.66
High Risk (Does Not Meet Standards)								
3	327	117.22 (43)	848.64 (28)	.64*	72.00	.92	.83	.87
4	318	136.52 (41)	848.33 (27)	.61*	101.00	.90	.83	.84
5	350	149.75 (40)	841.14 (25)	.57*	133.50	.80	.64	.68

Table 86. Diagnostic Accuracy of Fall CBMreading with Spring MCA-III in Reading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	CBMreading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	488	98.94 (42.72)	353.22 (22)	.71	89.5	.85	.74	.75
4	486	126.67 (46.38)	451.25 (22)	.70	126.5	.87	.79	.78
5	492	139.96 (40.73)	554.19 (16)	.73	131.5	.87	.78	.77
6	463	145.71 (39.80)	654.68 (19)	.68	143.5	.83	.76	.74
Some Risk (Partially Meets Standards)								
3	488	98.94 (42.72)	353.22 (22)	.71	--	.57	--	--
4	486	126.67 (46.38)	451.25 (22)	.70	127.5	.64	.70	.59
5	492	139.96 (40.73)	554.19 (16)	.73	137.5	.68	.72	.58
6	463	145.71 (39.80)	654.68 (19)	.68	151.5	.62	.70	.53
High Risk (Does Not Meet Standards)								
3	488	98.94 (42.72)	353.22 (22)	.71	77.5	.89	.78	.81
4	486	126.67 (46.38)	451.25 (22)	.70	109.5	.88	.80	.79
5	492	139.96 (40.73)	554.19 (16)	.73	116.5	.91	.82	.81
6	463	145.71 (39.80)	654.68 (19)	.68	132.5	.88	.77	.78

Table 87. Diagnostic Accuracy for Fall CBMreading with Spring Minnesota Comprehensive Assessment III (MCA-III) in Reading: MN LEA 2 (Fall to Spring Prediction)

Grade	N	CBMreading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	249	107.97 (42)	351.53 (28)	.71**	106	.82	.77	.77
4	236	134.75 (40)	452.51 (16)	.70**	131.5	.85	.76	.77
5	229	154.78 (36)	559.07 (15)	.65**	146.5	.85	.74	.73
Some Risk (Partially Meets Standards)								
3	249	107.97 (42)	351.53 (28)	.71**	97.5	.82	.77	.76
4	236	134.75 (40)	452.51 (16)	.70**	117.5	.89	.81	.80
5	229	154.78 (36)	559.07 (15)	.65**	129.5	.91	.88	.85

Table 88. Diagnostic Accuracy for Winter CBMreading with Spring Minnesota Comprehensive Assessment III (MCA-III) in Reading: MN LEA 2 (Winter to Spring Prediction)

Grade	N	CBMreading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	250	125.46 (41)	352.28 (26)	.73**	125.5	.83	.75	.76
4	240	149.38 (40)	451.76 (16)	.69**	148.5	.83	.76	.76
5	229	164.52 (34)	558.99 (15)	.65**	153.5	.87	.79	.77
Some Risk (Partially Meets Standards)								
3	250	125.46 (41)	352.28 (26)	.73**	--	.59	--	--
4	240	149.38 (40)	451.76 (16)	.69**	--	.60	--	--
5	229	164.52 (34)	558.99 (15)	.65**	152.5	.74	.70	.69
High Risk (Does Not Meet Standards)								
3	250	125.46 (41)	352.28 (26)	.73**	113.5	.85	.78	.79
4	240	149.38 (40)	451.76 (16)	.69**	135.5	.89	.80	.80
5	229	164.52 (34)	558.99 (15)	.65**	138.5	.91	.88	.85

Table 89. Diagnostic Accuracy for Winter CBMreading with MCA-III in Reading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	CBMreading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
3	496	123.11 (44)	353.06 (22)	.73	117.5	.86	.77	.79
4	497	145.20 (48)	450.97 (22)	.69	144.5	.87	.78	.76
5	497	159.21 (42)	554.22 (15)	.72	150.5	.86	.77	.79
6	466	162.05 (41)	654.55 (19)	.67	162.5	.81	.73	.73
Some Risk (Partially Meets Standards)								
3	496	123.11 (44)	353.06 (22)	.73	--	.56	--	--
4	497	145.20 (48)	450.97 (22)	.69	147.5	.63	.69	.56
5	497	159.21 (42)	554.22 (15)	.72	156.5	.65	.67	.54
6	466	162.05 (41)	654.55 (19)	.67	167.5	.58	.68	.50
High Risk (Does Not Meet Standards)								
3	496	123.11 (44)	353.06 (22)	.73	105.5	.90	.81	.82
4	497	145.20 (48)	450.97 (22)	.69	129.0	.88	.80	.79
5	497	159.21 (42)	554.22 (15)	.72	134.5	.93	.85	.85
6	466	162.05 (41)	654.55 (19)	.67	148.5	.88	.81	.83

Table 90. Diagnostic Accuracy of Winter CBMreading with Spring Massachusetts Comprehensive Assessment (MCA): MA LEA 1 (Winter to Spring Prediction)

Grade	N	CBMreading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk ("Warning" and "Needs Improvement")								
3	92	123.82 (38)	241.89 (14)	.71**	114	.82	.76	.75
4	93	134.33 (41)	238.40 (15)	.68**	132.5	.81	.73	.73
5	75	153.03 (26)	243.63 (13)	.66**	155.5	.90	.76	.74
Some Risk ("Needs Improvement")								
3	92	123.82 (38)	241.89 (14)	.71**	116.5	.68	.72	.64
4	93	134.33 (41)	238.40 (15)	.68**	134	.69	.72	.60
5	75	153.03 (26)	243.63 (13)	.66**	154.5	.88	.75	.77
High Risk ("Warning")								
3	92	123.82 (38)	241.89 (14)	.71**	90.5	.97	.88	.89
4	93	134.33 (41)	238.40 (15)	.68**	109.5	.89	.78	.79
5	75	153.03 (26)	243.63 (13)	.66**	130.5	.82	1.00	.80

aReading

aReading diagnostic accuracy was derived from a sample of 777 students in first through Fifth Grades from two suburban schools in the Midwest. In the sample, 116 students were in First Grade, 188 in second, 159 in third, 156 in fourth, and 158 in Fifth Grade. Gender of the sample was approximately 49% female and 51% male. Approximately 67% of students in the sample were White, 5% Black, 19% Asian/Pacific Islander, 5% Hispanic, 2% American Indian, and 2% unspecified. In addition, 10% of students were receiving special education services, and 10% of students were classified as having limited English language proficiency. Socioeconomic status information was not available for the sample, but the schools the students were drawn from had rates of free and reduced lunch of 13% and 23% in 2009–10. Cut scores for aReading to predict students "At Risk" and "Somewhat At Risk" for reading difficulties were developed for the Gates-MacGinitie Reading Tests–Fourth Edition (GMRT-4th; MacGinitie, MacGinitie, Maria, & Dreyer, 2000) and the Measures of Academic Progress (MAP). Categories for the former were defined as students scoring below the 40th and 20th percentiles of the local sample and cut scores for each category developed by an adjacent school district for MAP were used on this sample. An additional analysis regarding diagnostic accuracy of aReading using The Minnesota Comprehensive Assessments (MCAs) as the criterion measure is briefly discussed. At the beginning of the school year (October, 2010) students completed an aReading assessment. The measure was group administered via a mobile computer lab. Scaled scores were calculated for each student. In February 2011, the same students completed the GMRT-4th. Composite scores were available for all grades except Second Grade. Due to time constraints, one subtest could not be administered to Second Grade students (the only grade that requires three subtests to yield a composite score). As a result, comprehension subtest scores were used for analysis. The GMRT-4th was group administered by a team of graduate students. Administrators completed advanced coursework in psychological assessment and completed an in-service training to administer the test. Test booklets were hand scored and inter-rater reliability was 100% across all subtest and composite scores. MAP scores for spring testing were provided to the aReading team from school administrators.

Table 91 below presents the ROC curve analysis results for each grade for students at high risk and somewhat at risk using the Youden Index with the GMRT-4th. In addition, sensitivity, specificity, PPP and NPP are displayed for the each grade for each cut score. ROC curves across grades and risk levels were far from the diagonal line indicating that aReading predicts reading difficulties with much more accuracy than chance. Evaluation of the table below indicated that across grades, AUC statistics were extremely high, especially for students at high risk (Mdn = .92) and values were still high for students somewhat at risk (Mdn = .87). In addition, Sensitivity was higher for each grade when determining students at high risk compared to somewhat risk. Positive Predictive Power was higher across grades when predicting students at somewhat risk (Mdn = .72 versus .56) while the opposite was true for Negative Predictive Power (Mdn = .82 versus .96) respectively.

Table 91. Diagnostic Accuracy statistics for aReading and GMRT-4th

Grade	N	aReading Cut Score	Sensitivity	Specificity	PPP	NPP	AUC
High Risk – Below 20th Percentile[a]							
1	116	430	.88	.87	.66	.96	.94
2	188	461	.70	.93	.74	.92	.88
3	159	490	.97	.77	.50	.99	.92
4	156	495	.85	.92	.72	.96	.94
5	159	506	.85	.84	.59	.95	.87
Somewhat at Risk – Below 40th Percentile							
1	116	436	.76	.86	.81	.82	.91
2	188	477	.86	.71	.71	.86	.87
3	159	490	.82	.87	.78	.90	.89
4	156	506	.72	.82	.73	.81	.82
5	159	522	.83	.76	.71	.86	.85

Note. [a] *The 20th percentile was used for this sample, which should approximate the 15th percentile.*

A similar pattern of results emerged when predicting performance on the MAP (See Table 92). Compared to the GMRT-4th as a criterion, NPP was much higher when predicting MAP scores. This could be attributed to the fact that the base rate of students at risk was much lower for MAP scores. Data collection for Kindergarten and for grades 6–12 are ongoing, and results are pending.

Table 92. Diagnostic Accuracy Statistics for aReading and MAP

Grade	N	aReading Cut Score	Sensitivity	Specificity	PPP	NPP	AUC
High Risk - 20th Percentile[a]							
2	188	497	1	.73	.14	1	.89
3	159	517	.95	.76	.21	1	.95
4	156	537	.96	.78	.30	1	.94
5	159	537	1	.82	.20	1	.93
Somewhat at Risk - 40th Percentile							
2	188	490	.77	.84	.41	.96	.89
3	159	527	.89	.77	.46	.97	.89
4	156	537	.82	.87	.65	.94	.92
5	159	547	.93	.77	.39	.99	.88

Note. [a] The 20th percentile was used for this sample, which should approximate the 15th percentile.

Finally, diagnostic accuracy analyses were conducted with aReading and the Minnesota Comprehensive Assessment (MCA) to determine if aReading predicted state reading assessments. The MCA is a state test that helps school districts measure student progress toward academic standards and meets the requirements of the Elementary and Secondary Education Act (ESEA).

The sample consisted of 1,786 students in third, fourth, and Fifth Grades from eight schools in the upper Midwest (MCAs are not administered to students in grades K–1). In the sample, 631 students were in third, 618 students were in fourth, and 537 students were in Fifth Grade. Gender of the sample was approximately 50% female and 50% male. Ethnic breakdown was approximately 45% White, 23% Black, 8% Asian/Pacific Islander, 15% Hispanic, 0.8% American Indian or Alaska Native, and 9% multiracial. (These percentages were rounded and may not add to 100). In addition, 12% of students were receiving special education services. Socioeconomic status information was not available for the sample, but the schools the students were drawn from had rates of free and reduced lunch ranging from 16% to 83% in 2013.

Students completed the Adaptive Reading (aReading) assessment and MCAs during the spring of 2013. Students with incomplete data in aReading, or those students with incomplete MCA Achievement Level Scores were excluded from analyses.

ROC Analysis was used to determine diagnostic accuracy of FAST™ aReading with Spring MCA scale scores serving as the criterion measure. Students were disaggregated by grade level. Diagnostic accuracy was computed for students at "High Risk" and "Somewhat At Risk" on MCA Scale Scores. "High Risk" includes those students that did not meet standards. "Somewhat At Risk" includes those students who did not meet or only partially met standards. Diagnostic accuracy statistics are provided in Table 93. Data collection is ongoing for all grade levels.

Table 93. Diagnostic Accuracy for aReading and MCA-III

Grade Level	N	aReading M (SD)	MCA-III M (SD)	r(x,y)	Cut[a]	AUC	Sens.	Spec.
High Risk (Does Not Meet Standards)								

3	629	534 (27)	347 (21)	.82	524.5	.90	.82	.81
4	615	549 (28)	447 (16)	.81	536.5	.92	.84	.84
5	516	564 (32)	553 (16)	.84	544.5	.96	.89	.86
Somewhat High Risk (Does Not Meet or Partially Meets Standards)								
3	629	534 (27)	347 (21)	.82	532.5	.90	.83	.82
4	615	549 (28)	447 (16)	.81	550.5	.89	.82	.82
5	516	564 (32)	553 (16)	.84	556.5	.93	.84	.84

More recently, the following diagnostic accuracy statistics were derived from samples of students across various states, using various criterion measures.

Table 94. Diagnostic Accuracy of Spring aReading with Spring MAP in Reading: WI LEA 1 (Spring Data Collection)

Grade	N	aReading M (SD)	MAP M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (≤ 40th percentile)								
2	33	477.61 (22.09)	181.61 (19.34)	.90**	474.5	.96	.91	.86
3	26	496.19 (26.13)	195.65 (17.25)	.95**	499.00	1.00	1.00	.89
4	31	509.35 (13.51)	208.23 (13.25)	.83**	504.00	.94	.86	.87
5	28	514.29 (13.49)	211.11 (12.90)	.79**	514.5	.90	.89	.79
6	25	521.48 (19.44)	215.08 (11.56)	.85**	520.5	.92	.86	.83
Some Risk (20th to 40th percentile)								
2	33	477.61 (22.09)	181.61 (19.34)	.90**	473	.79	1.00	.70
3	26	496.19 (26.13)	195.65 (17.25)	.95**	499	.86	1.00	.73
4	31	509.35 (13.51)	208.23 (13.25)	.83**	504	.79	.75	.78
5	28	514.29 (13.49)	211.11 (12.90)	.79**	514.5	.72	.80	.65
6	25	521.48 (19.44)	215.08 (11.56)	.85**	520.5	.74	.75	.71
High Risk (≤ 20th percentile)								
2	33	477.61 (22.09)	181.61 (19.34)	.90**	466.00	.97	.86	.85
3	26	496.19 (26.13)	195.65 (17.25)	.95**	475.00	1.00	1.00	.92
4	31	509.35 (13.51)	208.23 (13.25)	.83**	501.00	1.00	1.00	.89
5	28	514.29 (13.49)	211.11 (12.90)	.79**	503.5	.95	.75	.87
6	25	521.48 (19.44)	215.08 (11.56)	.85**	514.5	1.00	1.00	.86

Table 95. Diagnostic Accuracy of Fall aReading with Spring MCA-III in Reading: MN LEA 3 (Fall to Spring Prediction)

Grade	N	aReading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does not Meet or Partially Meets Standards)								
3	482	484.45 (19.73)	353.43 (21.78)	.77	478.5	.89	.82	.82
4	485	496.62 (22.72)	452.05 (17.67)	.77	499.5	.89	.80	.82
5	495	504.87 (19.72)	554.17 (15.46)	.80	503.5	.91	.82	.81
6	459	511.37 (22.43)	654.81 (18.75)	.73	508.5	.85	.75	.76
Some Risk (Partially Meets Standards)								
3	482	484.45 (19.73)	353.43 (21.78)	.77	474.5	.89	.86	.71
4	485	496.62 (22.72)	452.05 (17.67)	.77	487.5	.94	1.00	.71
5	495	504.87 (19.72)	554.17 (15.46)	.80	499.5	.93	.94	.71
6	459	511.37 (22.43)	654.81 (18.75)	.73	504.5	.96	1.00	.70
High Risk (Does Not Meet Standards)								
3	482	484.45 (19.73)	353.43 (21.78)	.77	475.5	.90	.79	.83
4	485	496.62 (22.72)	452.05 (17.67)	.77	490.5	.92	.82	.82
5	495	504.87 (19.72)	554.17 (15.46)	.80	497.5	.93	.84	.85
6	459	511.37 (22.43)	654.81 (18.75)	.73	504.5	.89	.83	.81

Table 96. Diagnostic Accuracy of Winter aReading with Spring MCA-III in Reading: MN LEA 3 (Winter to Spring Prediction)

Grade	N	aReading M (SD)	MCA-III M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Does Not Meet or Partially Meets Standards)								
5	134	519.97 (15.30)	560.84 (13.80)	.77	514.5	.89	.83	.84
6	160	524.56 (18.42)	661.15 (16.55)	.70	520.5	.80	.70	.74
Some Risk (Partially Meets Standards)								
5	134	519.97 (15.30)	560.84 (13.80)	.77	514.5	.79	.71	.77
6	160	524.56 (18.42)	661.15 (16.55)	.70	522.5	.68	.74	.67
High Risk (Does Not Meet Standards)								
5	134	519.97 (15.30)	560.84 (13.80)	.77	510.5	.93	.80	.82
6	160	524.56 (18.42)	661.15 (16.55)	.70	514.5	.92	.83	.84

aReading evidence of diagnostic accuracy is not limited to the Midwest. The following diagnostic accuracy information was obtained from samples of students in other regions of the US.

Table 97. Diagnostic Accuracy Fall aReading with Spring Massachusetts Comprehensive Assessment (MCA): Cambridge, MA (Fall to Spring Prediction)

Grade	N	aReading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk ("Warning" and "Needs Improvement")								
3	93	485.91 (17.59)	241.89 (14.08)	.63**	478.5	.79	.73	.73
4	93	492.68 (18.52)	238.40 (15.14)	.69**	492.5	.85	.75	.78
5	72	506.93 (18.58)	243.63 (13.20)	.69**	507.5	.90	.85	.79
Some Risk ("Needs Improvement")								
3	93	485.91 (17.59)	241.89 (14.08)	.63**	480.5	.71	.72	.63
4	93	492.68 (18.52)	238.40 (15.14)	.69**	494.5	.72	.71	.60
5	72	506.93 (18.58)	243.63 (13.20)	.69**	506.5	.88	.78	.87
High Risk ("Warning")								
3	93	485.91 (17.59)	241.89 (14.08)	.63**	475.5	.80	.75	.72
4	93	492.68 (18.52)	238.40 (15.14)	.69**	476.5	.92	.89	.84
5	72	506.93 (18.58)	243.63 (13.20)	.69**	495.5	.85	1.00	.79

Table 98. Diagnostic Accuracy of Winter aReading with Spring Massachusetts Comprehensive Assessment (MCA): MA LEA 1 (Winter to Spring Prediction)

Grade	N	aReading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk ("Warning" and "Needs Improvement")								
3	91	498.99 (18.66)	241.89 (14.08)	.76**	499.5	.85	.76	.74
4	94	504.33 (16.37)	238.40 (16.37)	.69**	505.5	.85	.76	.78
5	74	515.31 (14.42)	243.63 (14.42)	.61**	516.5	.83	.82	.78
Some Risk ("Needs Improvement")								
3	91	498.99 (18.66)	241.89 (14.08)	.76**	501.5	.71	.72	.64
4	94	504.33 (16.37)	238.40 (16.37)	.69**	506.5	.71	.78	.64
5	74	515.31 (14.42)	243.63 (14.42)	.61**	516.5	.81	.81	.76
High Risk ("Warning")								
3	91	498.99 (18.66)	241.89 (14.08)	.76**	476.5	.97	.88	.95
4	94	504.33 (16.37)	238.40 (16.37)	.69**	485.5	.94	.78	.88
5	74	515.31 (14.42)	243.63 (14.42)	.61**	506.00	.86	1.00	.80

Table 99. Diagnostic Accuracy of Fall aReading with Spring CRCT in Reading: GA LEA 1 (Fall to Spring Prediction)

Grade	N	aReading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	329	483.81 (18)	848.65 (28)	.73*	481.50	.83	.76	.76
4	320	491.37 (16)	848.18 (27)	.64*	490.50	.80	.73	.75
5	353	497.81 (16)	841.22 (25)	.64*	499.50	.75	.70	.68
High Risk (Does Not Meet Standards)								
3	329	483.81 (18)	848.65 (28)	.73*	466.50	.94	.82	.86
4	320	491.37 (16)	848.18 (27)	.64*	478.50	.89	.83	.76
5	353	497.81 (16)	841.22 (25)	.64*	485.00	.89	.79	.79

Table 100. Diagnostic Accuracy of Winter aReading with Spring CRCT in Reading: GA LEA 1 (Winter to Spring Prediction)

Grade	N	aReading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
3	327	495.67 (18)	848.64 (28)	.75*	498.50	.83	.76	.76
4	318	505.31 (16)	848.33 (27)	.71*	505.50	.82	.77	.78
5	351	512.19 (15)	841.14 (25)	.66*	516.50	.78	.71	.72
6	283	518.78 (13)	850.14 (23)	.67*	519.50	.87	.77	.80
High Risk (Does Not Meet Standards)								
3	327	495.67 (18)	848.64 (28)	.75*	477.50	.95	.83	.86
4	318	505.31 (16)	848.33 (27)	.71*	487.50	.94	.83	.76
5	347	512.19 (15)	841.14 (25)	.66*	500.50	.92	.86	.85
6	283	518.78 (13)	850.14 (23)	.67*	NA	NA	NA	NA

These findings have also been demonstrated in higher grade levels. The following diagnostic accuracy information was obtained from a sample of approximately 322 7th grade students (50.0% female) and 311 8th grade students (50.3%) in a Georgia Local Education Agency (LEA). Approximately 74.7% of 7th grade students were White, 8.6% were Hispanic, 8.3% were African American, 5.6% were Multiracial, 2.5% were Asian, and .3% identified themselves as “Other.” Approximately 81.2% of 8th grade students were White, 7.3% were African American, 5.7% were Hispanic, 4.1% were Multiracial, 1.3% were Asian, and .3% identified themselves as “Other.” See Table 101 for diagnostic accuracy statistics.

Table 101. Diagnostic Accuracy of Winter aReading with Spring Criterion-Referenced Competency Tests (CRCT) in Reading: Georgia LEA 1 (Winter to Spring Prediction)

Grade	N	aReading M (SD)	CRCT M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
7	322	521.77 (14.86)	842.50 (24.09)	.64**	512.5	.91	.82	.81
8	311	524.69 (21.76)	850.36 (54.42)	.33**	517.5	.95	1.00	.73
High Risk (Does Not Meet Standards)								
7	322	521.77 (14.86)	842.50 (24.09)	.64**	509.5	.92	.86	.86
8	311	524.69 (21.76)	850.36 (54.42)	.33**	511.5	.92	.86	.84

Table 102. Diagnostic Accuracy of Fall aReading with Spring Minnesota Comprehensive Assessment III (MCA-III) in Reading: MN LEA 2 (Fall to Spring Prediction)

Grade	N	aReading M (SD)	MCA M (SD)	r(x,y)	Cut	AUC	Sens.	Spec.
Some Risk (Meets Standards)								
10	66	527.91 (18.59)	1052.29 (12.99)	.55**	523.5	.82	.77	.75
High Risk (Does Not Meet Standards)								
10	66	527.91 (18.59)	1052.29 (12.99)	.55**	521.5	.77	.75	.77

For additional diagnostic accuracy information for FastBridge Learning Reading Assessments, please see Appendix B: FastBridge Learning Reading Diagnostic Accuracy.

Section 6. FAST™ as Evidence-Based Practice

This section provides a summary of some evidence for FAST™ as an evidence-based intervention. The use of well-developed training and support with technology to deliver and automate the use of formative assessments and data improve student outcomes. FAST™ improves teacher knowledge, skills, and appreciation for data. The use of FAST™ changes teaching.

The graphic below is our theory of change, which relates to our hypothesis for systems change and improved student outcomes caused by the adoption and use of FAST™.

6.1: Theory of Change

FastBridge Learning and our researchers and developers have a theory of change (right). Our theory is that student outcomes improve when teachers use evidence-based formative assessments in conjunction with technology-based training and supports for data-based decision making. We provide evidence for this theory of change below.

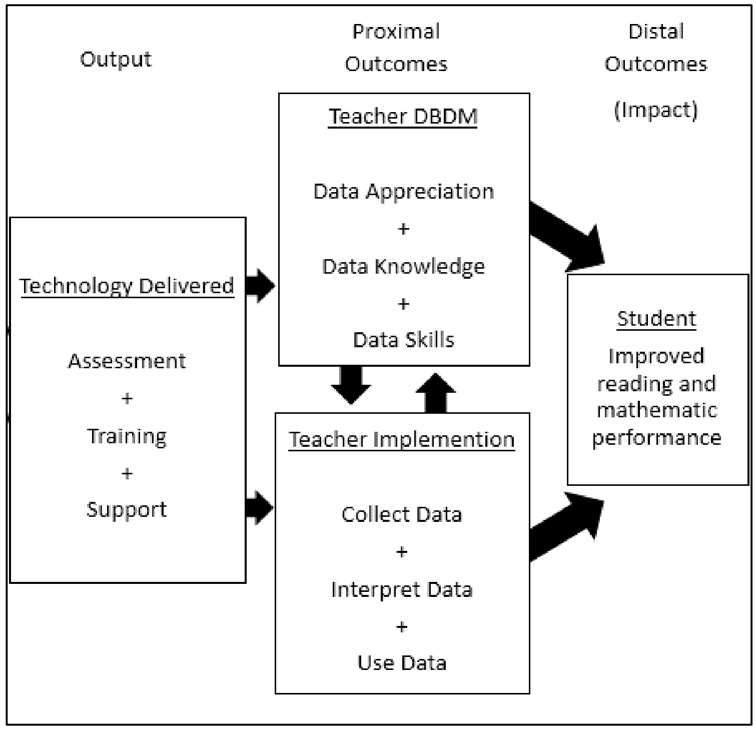

Figure 3 Theory of Change

FastBridge Learning's researchers and developers work continuously to refine and improve the tools. They work *with* teachers and educators to evaluate their needs and satisfaction. They collect and evaluate student data to ensure alignment with standards and improved student outcomes.

6.2: Formative Assessment as Evidence-Based Practice

Effective teachers use formative assessment to guide their practices. This is recommended and supported in the empirical and professional literature. Teachers and students benefit less from summative assessments, which occur infrequently, have little instructional relevance, and yield results that are often delayed for days, weeks, or months (e.g., many state testing programs).

Teachers need an effective formative assessment system. Effective systems provide assessments, reporting, and guidance for data interpretation and use. Moreover, they support the multi-method and multi-source approach, which requires multiple types of assessments with varied methods across the most relevant content areas.

US Department of Education

The US Department of Education's *Practice Guides* summarize the evidence and recommendations for effective practice (http://ies.ed.gov/pubsearch). They recommend formative assessment and evaluation.

Those guides were developed by panels of national experts who "relied on the WWC Evidence Standards" (Gersten, 2008, p. 2). After a review of the evidence, the expert panel for *Using Student Achievement Data to Support Instructional Decision Making* recommended that educators: (1) make data part of an ongoing cycle of instructional improvement, (2) have a clear vision for schoolwide data use, (3) foster a data-driven culture, and (4) maintain a districtwide data system (Hamilton et al., 2009, p. 8). The RTI reading panel found moderate evidence to recommend universal screening and progress monitoring for students with deficits (Gersten et al., 2008, p. 13). The RTI math panel made substantially similar recommendations (Gersten et al., 2009, p. 11).

All of the expert panels recommend the use of high-quality and highly efficient formative assessments. They also recommend the use of assessment data to plan instruction, differentiate instruction, titrate support (tiered services), devise instructional groups, monitor progress, and evaluate instructional effects. Some recommendations had lower levels of evidentiary support, but FAST™ is designed to facilitate the implementation of these recommended practices.

Historical Evidence on Formative Assessment

Effective teachers systematically collect and share student assessment data to help them make instructional decisions that improve student performance (Lipson, Mosenthal, Mekkelsen, & Russ, 2004; Taylor et al., 2000) by 0.4 to 0.7 standard deviations (Black & Wiliam, 1998).

Teachers should be able to use data to inform their practice (Martone & Sireci, 2009). After a thorough review of the pre-1990 research literature on effective instruction, Hoffman (1991) concluded that there is persistent and consistent evidence that the use of instructionally relevant assessments improved instructional effects and student achievement. Those findings converge with those of contemporary research. For example, Pressley et al. (2001) identified 103 behaviors that distinguished teachers who were either highly effective or moderately effective. Classroom assessment practices—as opposed to external assessments—were a major distinguishing factor in instructionally relevant assessments. That is, the use of formative assessment data to guide instruction contributes to more effective instruction and higher student achievement (Jenkins, 2001; Taylor, Pearson, Clark, & Walpole, 2000a, 2000b; Taylor, Pearson, Peterson, & Rodriguez, 2003, 2005).

Formative assessments guide both instruction and student learning. They provide feedback that is linked to explicit performance standards and provide guidance to achieve those standards (Sadler, 1989). Formative assessment helps establish a learning-assessment process, which is encapsulated by three key questions (Atkin, Black, & Coffey, 2001; Deno, 2002, 2005; Sadler, 1989):

- "What is the expected level of performance?"
- "What is the present level of performance?" and
- "What must be done to reduce that discrepancy?"

FAST™ provides useful data for educators to address each of these questions through screening, skills analysis, and progress monitoring. It also provides training, supports, analysis, and reporting to facilitate the use of data by teachers.

Evidence Based: Contemporary Evidence on Formative Assessment

Data-based decision making and formative assessment are evidence-based. Black and Wiliam (1998) and other common sources of evidence were cited above; however, the most recent and rigorous meta-analysis on formative assessment was done by Kingston and Nash (2011). The inclusion criteria for the meta-analysis were: (a) *formative assessment* was the intervention, (b) K–12 student samples, (c) control or comparison group, (d) appropriate statistics to estimate effect size, and (e) published 1988 or later. They identified 13 studies with 42 independent effect sizes, which allowed them to analyze the effects of professional development and computer-based formative assessment—among other things.

In brief, the weighed mean effect of formative assessment was .20 (*Mdn* = .25). The largest effects were observed in the content area of English language arts (.32) with less robust effects in mathematics (.17); however, there were statistically significant (moderating) effects for both professional development/training (.30) and technology-based formative assessments (.28). Results improved when teachers received training and technology to support the implementation and use of formative assessments. Preliminary evidence indicates that FAST™ is likely to confer even more substantial effects.

Although recent research (Kingston & Nash, 2011) indicates more modest effects for formative assessment, these are substantial and meaningful differences in student achievement.

As summarized in Table 103, if 80% of students are proficient (i.e., not in need of supplemental, intensive, or special education services) and formative assessment is implemented as an intervention, the proficiency rate is likely improve to 87% (assuming a .30 effect size). That is, the percentage of students with deficits or disabilities who need RTI or special education is reduced from 20% to 13%. That is a 35% reduction. Larger effects are observed with the implementation of FAST™. This is described as follows.

Table 103. Estimates of the Increase in the Percentage of Students who are Proficient or above with the Implementation of Formative Assessment (Kingston & Nash, 2011, p. 35)

Proficient	Percentage after Improvement of This Effect Size			
Initial Percent	**.20**	**.25**	**.30**	**.40**
20	26	28	29	33
50	58	60	62	66
80	85	86	87	89

Note. "While the weighted mean effect sizes found in this study are smaller than commonly reported in the literature, they have great practical significance in today's accountability climate. These improvements can be restated in terms of the percentage of students achieving summative assessment results at or above the proficient level. Table 350 shows the improvement that would result from several different effect sizes based on how many students are currently proficient or above (assuming scores are distributed normally). If currently 20% of students are proficient or above, then the weighted mean effect size of .20 would lead to an additional 6% of students achieving proficient status. If currently 50% of students are proficient or above, then the increase would be 8%. The .30 effect size associated with formative assessment based on professional development would lead to 9% and 12% of all students moving into the proficient category under these two scenarios." (Kingston & Nash, pp. 34-35).

Formative assessment is an evidence-based practice with the most robust effects when it is delivered with technology, training, and support. The evidence summarized by Kingston & Nash (2011; *N* = 13 studies, 42 effect sizes) meets the What Works Clearinghouse criteria for "Positive effects: Strong evidence of positive effect with no overriding contrary evidence" (WWC, 2014, p. 29).

6.3: Evidence-Based: Formative Assessment System for Teachers

FAST™ combines all aspects of those evidence-based practices described above: technology tools for assessment, training, and support. Two sources of evidence are presented to illustrate that the implementation and use of FAST™ is an evidence-based practice.

FAST™ Improves Student Achievement

We analyzed grade-level performance of suburban Midwestern local educational agencies (Schools = 8) with aReading data (broad measure of reading achievement). Performance data from the fall of year 1 implementation (i.e., pre-test) were compared to fall of year 2 implementation (e.g., post-test) to evaluate the effect of FAST™. That is, the difference in performance between second graders in 2013 (control, *M* = 445) and second graders in 2014 (after teachers implemented FAST™ for one year; *M* = 451) might be attributed, in part, to the FAST™ implementation.

There were statistically significant differences with meaningful effect sizes in both general and special education samples (Table 104, p. 125). This was observed at the district and school levels. Although not all differences were statistically significant (viz., special education) that is attributed to statistical power—as effect sizes were still robust. The observed effect sizes converge with the findings of Kingston and Nash (2011). These are meaningful and important improvements that replicated across all grades and populations except 6th grade special education.

If combined with the estimates in Table 103, **FAST™** is likely to reduce the proportion of students at risk and increase the proportion who achieve proficiency by 7 to 13%--or more.

Table 104. FAST™ Statistical Significance and Effect Sizes

		2013			2014						
Grade	Group	M	SD	N	M	SD	N	t	df	p	d
2nd	GenEd	463.3	25.8	578	469.5	27.7	523	3.80	1099	.00*	.23
	SpEd	445.6	25.1	51	451.6	33.9	46	.10	95	.32	20
3rd	GenEd	484.5	19.3	507	492.4	24.3	559	5.83	1064	.00*	36
	SpEd	470.2	25.7	46	474.6	26.6	57	.86	101	.40	17
4th	GenEd	498.3	22.0	507	504.6	21.7	513	4.61	1018	.00*	29
	SpEd	476.7	26.1	62	487.9	28.8	52	2.17	112	.03*	41
5th	GenEd	504.3	19.4	483	514.7	23.2	505	7.54	986	.00*	48
	SpEd	490.8	26.1	76	498.5	24.9	64	1.77	136	.08	30
6th	GenEd	508.8	25.1	431	522.3	24.1	475	8.23	904	.00*	.55

		2013			2014						
Grade	Group	M	SD	N	M	SD	N	t	df	p	d
	SpEd	506.3	20.0	71	506.1	29.5	80	-.04	149	.97	.01

Note. Adaptive Reading (aReading) is a computer-adaptive test of broad reading on a score scale range of 350 to 650, which spans K to 12th grade achievement. Aggregate data are presented for 8 schools. Grade level performance was compared across the first two years of implementation.

FAST™ Improves the Practice of Teachers

An independent survey of teachers (*N*=2689 responses) by the Iowa Department of Education indicates that 86% of educators believe FAST™ "may" or "will definitely" support increased student achievement (Greg Felderman, Iowa Department of Education, personal communication, January 2015). It also indicated that teachers use data to guide instruction and improve student achievement.

- 82% of teachers used FAST™ assessment data to form instructional groups (*N* = 401 teachers responded),
- 82% adjusted interventions for students with deficits or disabilities (*N* = 369); 66% used data at least once per month (66%), and
- 25% used FAST™ data at least weekly (*N* = 376).

These results provide insight as to the effects of FAST™ implementation.

FAST™ Provides High Quality Formative Assessments

As summarized above, the IES practitioner guides recommend the use of high quality assessments. The FAST™ assessments meet the IES recommendations for quality: reliability, validity, usability, efficiency, diagnostic accuracy, specificity, sensitivity, efficiency, and instructional relevance.

The FAST™ assessments are evidence-based. Numerous studies were completed with diverse samples of students across many geographic locations and LEAs (e.g., NY, GA, MN, IA, and WI). Consistent with the definitions of "evidence-based," there are many large, multi-site studies with student samples from the populations and settings of interest (i.e., K–12 students). The samples size for almost all studies well-exceeded the requirement of 50 students per condition (e.g., assessment, grade, LEA, instructional condition). On aggregate, more than 15,000 students participated in well-controlled psychometric research. In addition, norms were developed from samples of approximately 8,000 students per grade (K to 8th) per assessment, which aggregates to 72,000 student participants. Consistent with the requirements for evidence, the psychometric qualities for reliability and validity were statistically significant, and the various assessments are meaningful and statistically robust indicators of relevant outcomes, such as state tests and future performance in school.

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Appendix A: Benchmarks and Norms Information

Norms and benchmarks are reported in the FastBridge Learning Benchmarks and Norms Guide, 2015-2016.

Appendix B: FastBridge Learning Reading Diagnostic Accuracy

Table 105. Summary of Diagnostic Accuracy AUC Statistics and Validity Evidence

Grade	Measure	Subtest	F to W AUC	W to S AUC	F to S AUC	Concurrent Validity (Spring)
K	earlyReading	Concepts of Print	.80 -.81	—	—	pending
		Onset Sounds	.83 - .84	—	—	pending
		Letter Names	.78 - .82	—	—	pending
		Letter Sounds	.80 - .82	—	—	pending
		Composite	.82 - .84	.84	.73–.76	pending
1	earlyReading	Letter Sounds	.73 - .99	.76–.77	.75–.78	pending
		Word Rhyming	—	.71–.75	—	pending
		Word Segmenting	.87	—	—	pending
		Nonsense Words	.66 - .89	—	—	pending
		Sight Words	.69 - .92	—	—	pending
		Sentence Reading	.71 - .94	.82–.92	.72	pending
		Composite	.85 - .89	—	—	pending
2	aReading	—	—	—		.96–.97
	CBMreading	—	—	—		.97 –.99
3	aReading	—	—	.83–.97	.76–.90	.78–1.00
	CBMreading	—	—	.76–.97	.79–.97	.77 –1.00
4	aReading	—	—	.77–.94	.75–.92	.79–1.00
	CBMreading	—	—	.78–.90	.81–.89	.71–1.00
5	aReading	—	—	.71–.93	.68–.93	.78–.96
	CBMreading	—	—	.71–.93	.71–.91	.69–.97
6	aReading	—	—	.77–.92	.83–.89	.86–1.00
	CBMreading	—	—	.81–.88	.83–.88	.81–1.00
7	aReading	—	—	.91–.92	.81–.85	pending
8	aReading	—	—	.92–.95	.69–.85	pending
9	aReading	—	—	—	.85–.87	pending
10	aReading	—	—	—	.77–.82	pending

Note. F = Fall; W = Winter; S = Spring