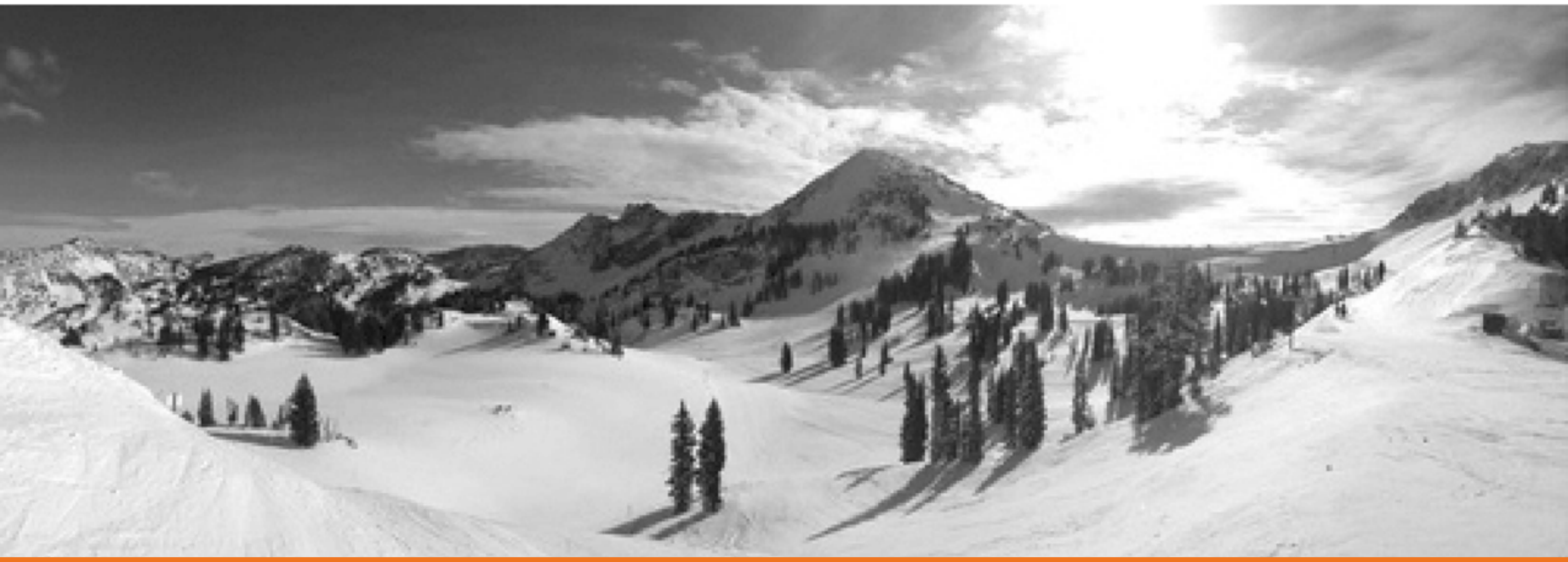
Colorado Measures of Academic Success



Technical Report

Math and English Language Arts (ELA)

2019

Colorado Measures of Academic Success (CMAS)
Mathematics & ELA (including CSLA)
Technical Report
2019

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PART I: HISTORICAL OVERVIEW AND SUMMARY OF PROCESSES

CHAPTER 1: INTRODUCTION

Requirements

All public-schools in Colorado are required by state law to administer a standards-based summative assessment each year in specified content areas and grade levels. Every student, regardless of ability or language background, must be provided with the opportunity to demonstrate their content knowledge through the state assessments. The Colorado Measures of Academic Success (CMAS) assessments in mathematics and English language arts (ELA) are Colorado's end-of-year standards-based assessments designed to measure students' achievement of the grade-level Colorado Academic Standards (CAS) in those content areas at grades 3-8.

As a requirement of Colorado School Law C.R.S. §22-7-1006.3 (4) (a) and (b), English learners with Spanish as their home language in grades 3 and 4 who meet established eligibility criteria may take the Colorado Spanish language arts (CSLA) forms of the CMAS ELA assessment. The Spanish forms are considered accommodated versions of CMAS. As a result, CSLA forms are developed to be parallel and comparable to the other CMAS forms in test design, item type, scoring, and reporting. To maintain this comparability, the revised CMAS ELA blueprints were used to develop the CSLA forms administered during the spring 2019 administration.

CMAS assessments were originally developed as online assessments. Colorado legislation (C.R.S. §22-7-1006.3 (1) (d)) requires that a paper-based version be available for all online assessments which may be selected by local educational providers to be administered to their students. These decisions may be made by grade and content area. The comparable paper-based forms may also be administered to students with disabilities and English learners as appropriate in schools that otherwise are administering the online forms of the assessments.

In 2015, Colorado passed legislation (C.R.S. §22-7-1013 (8) (a-c)) that allows for parents to excuse their child(ren) from testing.

Intended Population

The CMAS assessments are intended to be taken by all students enrolled in public schools in grades 3-8 with the exception of some students with the most significant cognitive disabilities who may take the Colorado Alternate Assessment (CoAlt): ELA and Mathematics (DLM) assessments as determined by the student's IEP or other educational team. English learners in their first year in the United States are exempt from the ELA assessment. However, 3rd and 4th grade English learners designated as not English proficient (NEP) whose native language is Spanish and who have received language arts instruction in Spanish during the current school year are required to take CSLA. Students with disabilities and English learners may take the CMAS assessments with or without accommodations that do not change the construct of the assessment. Accommodations are determined based on classroom experience and educational team decisions.

Purpose of CMAS

CMAS assessments were designed from the start to be used for a variety of purposes, including serving as one uniform indicator to inform parents and educators about individual student achievement of the grade-level CAS and allowing comparisons to other students across the state. Results are also used as a piece of information in the evaluation of educator, school and district performance.

CMAS is a source of data that:

- may be used as a prompt for further investigation at the student, classroom, school, and district levels
- supports districts/schools in reviewing and developing goals for the performance of their students, including subgroups
- may indicate that a review of programs, curricula, materials and/or scope and sequence may be appropriate
- may inform the evaluation of district/school approaches

Assessment results also support a range of data-driven stakeholder conversations, activities, and decisions, including school selection, program evaluation, investigative research, and policy/legislation formation and review.

Purpose of this Document

The purpose of the *CMAS mathematics and ELA (including CSLA) Technical Report* is to inform users and other interested parties about the development, content, and technical characteristics of the CMAS assessments. The technical report provides information about the planning and administration of the spring 2019 exams.

This report is divided into two parts. Part I presents an overview and summary of the components of the program. Information regarding the planning and administration of the assessments as well as details regarding item development, item banking, test construction, administration procedures, scoring, reporting, reliability, and validity are included in Part I of the document. Part II provides a statistical summary of the spring 2019 administration. Results are provided for both the operational items and the embedded field test items.

Background

Prior to spring 2018, Colorado developed CMAS mathematics and ELA assessments in collaboration with the Partnership for Assessment of Readiness for College and Careers (PARCC) consortium. For information on the background of the consortium and the development and administration of the 2015-2017 assessments, see prior years' *PARCC Final Technical Reports*.

In 2017, the State Board of Education provided direction to the department to decrease testing time. CDE began exploring the use of abbreviated versions of the prior years' test blueprints with the goal of decreasing testing time while retaining comparability to the CMAS mathematics and ELA assessments previously administered in Colorado in order to maintain longitudinal trend data. Assessment forms based on abbreviated blueprints were developed during the fall of 2017 and administered beginning with the spring 2018 administration. For more information about the transition and abbreviated assessments, see the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018*. The 2019 assessments described in this report represent the second administration of assessments based on the abbreviated blueprints.

Assessment Development Partners

A portion of the 2019 operational assessment items were developed solely by Colorado and field-tested on the 2018 assessments. The remaining 2019 operational assessment items were licensed from New Meridian and selected from the bank of items developed in collaboration with the PARCC consortium. For more information about items developed prior to 2018, refer to the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018*.

Activities specific to the CMAS assessments were conducted collaboratively by the Colorado Department of Education (CDE), the Colorado educator community, and the assessment contractor, Pearson. In addition, input and advice were provided by the Colorado Technical Advisory Committee (TAC).

Colorado Department of Education

As the administrative arm of the State Board of Education, CDE is responsible for implementing state and federal education laws. CDE's Assessment Unit works closely with Colorado school districts, educators, community stakeholders, and assessment development partners to develop and administer the state assessments. CDE focuses on creating assessments that serve students, schools, districts, and the community while complying with state and federal legal requirements. CDE content, assessment administration, special populations, technology, data and psychometric staff work closely with Pearson on each facet of the assessment with CDE serving as the ultimate approver of services and products provided.

Colorado Educator Community

Educator participation in the CMAS development process is critical to ensuring that the assessments are aligned to the Colorado Academic Standards, appropriate for Colorado students at the assessed grade level, and free from potential bias and sensitivity issues. Throughout item and assessment development, educators participate in the following development activities:

- Item Writing: After receiving item writing assignments based on the academic standards, educators create assessment items. Items that successfully move through the entire item development process will eventually appear on the operational assessments. (Operational items that were written by Colorado educators were included on the CMAS mathematics and ELA assessments for the first time in spring 2019.)

- Content and Bias Review: Educators review items to ensure content alignment and identify potential bias and sensitivity concerns before items are included on the embedded field test.

- Rangefinding: Educators review student responses to field tested constructed response items and define the score point ranges for the scoring rubrics that are used to score student responses.

- Data Review: Before field tested items are included on operational assessments, educators review data to identify potential construct-irrelevant explanations for statistical flags.

Pearson

As the primary contractor responsible for end-to-end of the 2019 assessment cycle services and products, Pearson worked closely with CDE throughout the CMAS (all content areas) and CoAlt (science and social studies) assessment development and administration processes. This included item and test development, online and paper forms creation, enrollment, packaging and distribution, online test delivery, processing, scoring, customer service, standard setting, scoring, reporting, and psychometric services.

Tri-Lin Integrated Services, Inc.

As a subcontractor to Pearson, Tri Lin was responsible for CSLA content and test development. This included passage development, item development, and test form construction.

Colorado Technical Advisory Committee (TAC)

The Colorado TAC was comprised of psychometric, assessment, and special populations experts tasked with providing high-level consulting and expert advice regarding validity and reliability issues, including psychometric topics of the CMAS assessments. Topics for which the TAC provided input included blueprint design, scaling and equating, scoring, reporting, and comparability. The TAC included the following members:

- Dr. Jamal Abedi, Professor, University of California, Davis
- Dr. Elliot Asp, Senior Partner, The Colorado Education Initiative
- Dr. Jonathan Dings, Executive Director of Student Assessment and Program Evaluation, Boulder Valley School District
- Dr. Lisa Escarcega, Executive Director, Colorado Association of School Executives
- Dr. Michael Kolen, Psychometric Consultant
- Dr. Martha Thurlow, Director, National Center on Educational Outcomes

Composition of the Assessments

CMAS assessments are standards-based tests designed to measure what students should know and be able to demonstrate at the end of each grade at the elementary and middle school levels (grades 3-8). Evidence statements reflecting college and career ready standards were developed to guide the development of the assessments. The spring 2019 CMAS mathematics and ELA (including CSLA) assessments were aligned to these evidence statements and subsequently mapped to the Colorado Academic Standards (CAS) in mathematics and reading, writing, and communicating:

- Math CAS: http://www.cde.state.co.us/comath/statestandards
- Reading, Writing, and Communicating CAS: http://www.cde.state.co.us/coreadingwriting/statestandards
- Evidence Statements: https://www.cde.state.co.us/assessment/cmas_testdesign

Claim Structures

The claim structures (master, major and subclaims) for the mathematics and ELA assessments, including Spanish forms, were grounded in the academic standards and informed the design and development of the assessments.

Claim Structure for Mathematics

- **Master Claim** – The master claim makes a statement about the degree to which a student is on track to being ready for the next grade in mathematics based on their achievement of the grade-level CAS.
- **Subclaims** – The subclaims are intended to provide more granular information about student demonstration of the knowledge and skills within the math content area as reflected in the CAS. The content reflected in each of the subclaims is provided below:
    - **Subclaim A**: Major Content with Connections to Practices
    - **Subclaim B**: Additional and Supporting Content with Connections to Practices
    - **Subclaim C**: Highlighted Practices with Connections to Content – Mathematical Reasoning
    - **Subclaim D**: Highlighted Practice with Connections to Content – Modeling and Application

Claim Structure for English language arts

- **Master Claim** – The master claim makes a statement about the degree to which a student is on track for being ready for the next grade in English language arts based on their achievement of the grade-level CAS.

- **Major Claim** – The major claim provides information on a student's achievement of reading and comprehending a range of sufficiently complex texts independently.

- **Subclaims** – The subclaims are intended to provide more granular information about student demonstration of the knowledge and skills within the ELA content area as reflected in the CAS. The content reflected in each of the subclaims is provided below:
    - **Vocabulary, interpretation, and Use**
    - **Reading Literature**
    - **Reading Informational Text**
    - **Written Expression**
    - **Knowledge of Language and Conventions**

Score Structure

Master claim: The degree to which a student demonstrated the concepts and skills represented in the master claim is reported through both a performance level and a scale score. There are five performance levels based on a scale score range of 650-850. Both policy and specific grade-level performance level descriptors are reported. The policy level performance levels and associated scale score ranges are provided below.

CMAS Policy Level Performance Level Descriptors and Associated Overall Scale Scores					
	Did Not Yet Meet Expectations	**Partially Met Expectations**	**Approached Expectations**	**Met Expectations**	**Exceeded Expectations**
Performance Level Descriptor	Students who do not yet meet academic expectations for the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will *need extensive academic support* to engage successfully in further studies in this content area.	Students who demonstrate a limited command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will *need additional academic support* to engage successfully in further studies in this content area.	Students who demonstrate a moderate command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will *likely need additional academic support* to engage successfully in further studies in this content area.	Students who demonstrate a strong command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They are *academically prepared* to engage successfully in further studies in this content area.	Students who demonstrate a distinguished command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They are *academically well prepared* to engage successfully in further studies in this content area.
Scale Score	650-699	700-724	725-749	750-varies*	varies*-850

*Varies by grade and content area.

Major claim: (ELA only) - The degree to which a student demonstrated the concepts and skills represented in the reading major claim is reported through a scale score with a range of 110-190. The writing major claim is reported as percent of points earned.

Subclaims: The degree to which a student demonstrated the concepts and skills represented in the subclaims is reported as percent earned. These percentages are not comparable across years.

Test Structure

Test Structure for Mathematics

The mathematics assessments contain selected-response (SR) items, technology-enhanced (TE) items, and constructed-response (CR) items and include three types of items:

Type I:

- Tasks assessing concepts, skills and procedures
- Subclaims A and B
- 1-point and 2-point items (grades 3-8) and 4-point items (grade 6-8)
- SR and TE items
- Calculator (grade 6-8) and noncalculator (grade 3-8)

Type II:

- Tasks assessing expressing mathematical reasoning
- Subclaim C
- 3- or 4-point items
- SR, TE, and CR parts, all items will have at least one CR part
- Calculator (grades 6-8), noncalculator (3-5)

Type III:

- Tasks assessing modeling/application
- Subclaim D
- 3- or 6-point items
- SR, TE, and CR parts, all items will have at least one CR part
- Calculator (6-8), noncalculator (3-5)

Test Structure for English Language Arts

The ELA assessments are passage based with a combination of literary and informational passages. Multiple passages may be used to respond to some questions. The ELA assessments contain selected-response (SR) items, technology-enhanced (TE) items, and Prose Constructed Response (PCR) tasks. For PCRs, students receive a prompt, respond to reading questions and write an extended response, which is scored on a multi-trait rubric (knowledge of language and conventions, and written expression) (see Appendix A). ELA PCRs include three types of tasks: literary analysis, research simulation, and narrative writing.

CSLA forms are developed to be parallel and comparable to the other CMAS paper forms in test design, item type (SR and PCR), scoring, and reporting. To maintain this comparability, the abbreviated CMAS ELA blueprints were used to develop the CSLA forms administered during the spring 2019 administration.

Test Blueprints

CDE and Pearson collaborated in designing the CMAS mathematics and ELA grade-specific blueprints. For more information about this process, see the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018*. The blueprints can be found in Figures 1-4.

Timing of Tests

Each 2019 assessment was composed of three sections with field test items embedded. The timing of the sections varied by grade and content area as indicated below:

2019 CMAS Testing Times		
	ELA	**Math**
Grades 3-5	Sections 1-3: 90 minutes Total time: 270 minutes	Sections 1-3: 65 minutes Total time: 195 minutes
Grades 6-8	Sections 1-3: 120 minutes Total time: 360 minutes	Sections 1-3: 65 minutes Total time: 195 minutes

CHAPTER 2: ITEM DEVELOPMENT AND ITEM BANKING

For details about item and task design and development that occurred prior to the development of the Spring 2018 CMAS field test items, refer to the *PARCC Final Technical Report for 2017 Administration* (Pearson, 2018).

Item Development

Operational Items

Computer-based Items

As discussed in the previous chapter, a portion of the operational items on the 2019 CMAS forms were items that had been used operationally on previous CMAS forms, while the remaining items were "refreshed" using Colorado-developed items that were field-tested in spring 2018. These newly operational items for 2019 were reviewed by Colorado educators exclusively, while previously used items had been reviewed by Colorado educators as well as educators from other consortium states.

Paper-based TEIs

The CMAS paper form was developed to be parallel to the online form, meaning the same passages and items appear on both the paper and computer-based forms. To support that, parallel paper-based items were developed for TEIs in a way that was comparable in terms of student interaction. In some cases this was achieved with traditional selected-response items and in others it required an item that had to be human-scored. For example, a drag-and-drop item may have been converted to an item in which the student had to draw lines from the draggers to the drop bays.

Field Test Items

Spring 2019 field test items were developed solely by Colorado. Field test items that appeared on the 2019 assessment were reviewed by committees of Colorado educators exclusively. For each of these meetings, an effort was made to involve educators who were representative of the entire state of Colorado (geographic, gender, and race) and familiar with the Colorado Academic Standards, related instruction, and the assessment interaction and demonstration of achievement of the CAS of different groups of students, including students with disabilities and English learners, taking the CMAS assessments. The following section describes the item development process for the spring 2019 CMAS, including CSLA, field test items.

The validity of a state assessment relies on the methodology that frames the development and design of the assessment. In support of that claim, Pearson upheld these considerations as the cornerstones of the CMAS (including CSLA) item and test development:

- The item development process ensures the CMAS (including CSLA) items align to the Evidence Statements (ESs).
- CMAS (including CSLA) item development plans were designed to produce and maintain a robust item bank; items are written to address the scope of measured standards, grade-level difficulties, and cognitive complexity.
- For CMAS (excluding CSLA), the item and test development processes promote the equivalency of the online and paper-and-pencil assessments.
- CMAS items were developed with the intention of being administered on multiple testing platforms.
- CMAS (including CSLA) item and test development processes are compliant with industry standards.

The item-writing process used for developing the 2019 field test items was a tiered, inter-related process that began with the development of the test blueprints for each grade level within each subject, continued with designing the item development plan (IDP), and used the IDP to forecast the targeted number of items and associated stimuli across ESs needed to create a robust item bank that would be refreshed over time. Once written, the items went through multiple rounds of review; including contractor, department, and Colorado educator content, bias and data reviews.

Item Development Plan (IDP)

The IDP was designed to determine the number of passages (ELA, including CSLA, only) and items for each ES needed to construct the assessment based on the blueprint requirements. The item bank was analyzed, and ES, task type, and cognitive complexity gaps were identified. A variety of item types aligning directly to the ESs and to the corresponding Colorado Academic Standards were created during the development process.

Each IDP was updated at the beginning of the item development cycle with development targets that address any task model, passage type, ES, item/task type, and cognitive complexity shortages.

Passage Selection/Development

The initial step of development for CMAS ELA began with the research and selection of high-quality literary and informational texts. Due to availability of appropriate passages and challenges with acquiring permissions, passages to be used on the CSLA forms were commissioned. The number and types of needed passages were determined by the CMAS test construction specifications, a gap analysis of the pool of available passages, and the item development plan. The text/passage selection (and writing) guidelines, task model descriptions and cognitive complexity framework defined the number of texts/passages by text type, genre, length, and complexity. Contractor assessment specialists trained passage searchers to find (or write for CSLA items) relevant and rich texts that permitted a range of content to be developed. The guidelines and descriptions were consistent with what had been used in prior years' development.

Passage searchers and writers submitted the passages for contractor assessment specialists to review and evaluate using approved criteria, including adherence to the cognitive demand, relevance, and purpose of the test and the appropriate use of graphics as needed to improve text comprehension. Test passages were analyzed and rated for text complexity. Contractors checked passages for clarity, correctness of language, appropriateness of language for the grade level, and adherence to style guidelines.

Accepted passages were then presented to CDE for review. Once the passages were accepted by CDE, committees of educators reviewed them for content and bias. The committees were comprised of educators from throughout the state representing a variety of student populations including students with disabilities and students with limited English proficiency. Passages accepted by both CDE and recommended by the educator committees were then prepared for item writing.

Item Writing

Upon approval of the passages for ELA and CSLA, and the IDP for ELA, CSLA, and mathematics, Item Writer Workshops were conducted and facilitated by contractor assessment specialists. Item writing assignments were given to Colorado educators. For CSLA items, item writers proficient in written academic Spanish developed CSLA items after receiving training.

These items writers for CMAS (including CSLA) developed a variety of items, across task types and across ESs. The item writers worked with Pearson and/or Tri-Lin assessment specialists when clarification was needed. Item writers used the ESs; the Colorado Academic Standards (CAS); secure item specification documents, including item-writing guidelines (universal design guidelines, bias and sensitivity guidelines, and editorial guidelines); and the item writing checklist to guide them in completing their assignments. These resources were consistent with what had been used in prior years.

Item writers authored the items in ABBI, where Pearson or Tri-Lin assessment specialists completed their initial review. The assessment specialists reviewed and suggested revisions to the items and metadata for the item authors. The item writers made the revisions and resubmitted the items within ABBI.

Contractor Item Review for Quality Assurance

After items were written, Pearson and Tri-Lin assessment specialists evaluated each item specifically for content correctness; grade appropriateness; and ES, CAS, and cognitive complexity alignment. The assessment specialists focused on the quality of the items, adherence to the principles of universal design, cognitive demand, relevance to the purpose of the test, and appropriateness of graphics. Research librarians performed additional fact checking to ensure accuracy.

Pearson and Tri-Lin copy editors checked items for clarity, correctness of language, appropriateness of language for the grade level, adherence to style guidelines, and conformity with acceptable item-writing practices.

When appropriate, CR items were also reviewed for their scorability by a performance scoring director, and items and/or scoring guidelines (rubrics) with score points deemed “difficult to score” were revised in collaboration with the assessment specialist(s) at this point in the process. Equation editor items were reviewed for their scorability by a digital content development specialist.

Pearson and Tri-Lin assessment specialists also performed a universal design review to assess item accessibility irrespective of diversity of background, cultural tradition, and viewpoints; to evaluate changing roles and attitudes toward various groups; to review the role of language in setting and changing attitudes toward various groups; to appraise contributions of diverse groups (including ethnic and minority groups, individuals with disabilities, and women) to the history and culture of the United States and the achievements of individuals within these groups; and to edit for inappropriate language usage or stereotyping with regard to sex, race, culture, ethnicity, class, disability, or geographic region. The universal design review also included reviewing items for potential bias to ensure that all test items were fair, and that all students would have an equal opportunity to demonstrate achievement regardless of their gender, ethnic background, religion, socio-economic status, disability or geographic region. In addition, items were reviewed for visual bias, accessibility for students with disabilities, and convertibility to braille and text-to-speech.

Once the internal reviews were completed, each item’s status was updated in ABBI, and the lead assessment specialist conducted a final content review. Item statuses were updated in ABBI upon approval, and items were presented to CDE for review.

Adhering to these resources ensured that each Colorado item measured the ES and standard, was content- and grade-appropriate, was factually accurate, had appropriate answers and distractors, was accessible to all populations required to take the assessments, was free from any bias, and followed the Colorado style.

CDE Pre-Review

CDE reviewed items in ABBI to ensure that the content was correct, the alignment was sound, the cognitive complexity was appropriate, the language and content were grade-appropriate, the graphics were clear and relevant to the item, and free of bias/sensitivity issues.

When CDE completed its review of the CMAS (including CSLA) items, CDE alerted Pearson or Tri-Lin assessment specialists. CDE's comments and determinations regarding the status ("Accept," "Accept with Edits," or "Reject") of the items were recorded in ABBI.

- Items marked "Accept" needed no more revisions and were ready for Content and Bias review.
- Items marked "Accept with Edits" were revised per CDE's feedback and, if necessary, re-reviewed by content editors, research librarians, etc. These items were re-reviewed by CDE and reconciled with Pearson's assessment content specialist and either deemed "Accept" or "Reject."
- Items marked "Reject" were rejected and given a status of "Do Not Use" in ABBI. These items were either rewritten or replaced with items written by an assessment content specialist. In either case, the items went through the same rigorous review process as new items.

Content and Bias Review

Following the completion of the internal Pearson, Tri-Lin, and CDE reviews, Content and Bias Review Committees comprising Colorado educators was convened. The purposes of this educator review were to (1) ensure the items were properly aligned to the content standards, accurately measured intended content, and were grade-appropriate, and (2) identify any potential bias or stereotype in test items. Separate committees were convened for CMAS mathematics, ELA, and accommodated CSLA items. Each committee was comprised of Colorado educators from across the state with diverse backgrounds and experience working with diverse (gender, race/ethnicity, income, geography, etc.) learners, standards and content expertise, and special population (students with disabilities and English learners) expertise. For accommodated CSLA items, an effort also was made to involve educators who teach ELs, were familiar with the instruction and needs of the students in an English language development program that utilizes native language instruction, and were proficient in written Spanish. The meetings were conducted either in person or virtually. They included group training on the expectations and processes of each meeting, followed by breakout groupings into grade/subject working committees where additional training was provided.

The committee members were trained and instructed to verify that each stimulus and item (list non-exhaustive):

- used clear, unambiguous, and grade-level appropriate language;
- avoided construct-irrelevant complex sentence structure;
- used everyday words to convey meaning when vocabulary was not part of the tested construct;
- had one correct answer (depending on the item type);
- contained plausible distractors that represented feasible misunderstandings of the content (depending on the item type);
- represented the range of cognitive complexities and included challenging items for students performing at all levels;
- was appropriate for students in the assigned grade in terms of reading level, vocabulary, interest, and experience;
- had scoring guidelines that captured exemplar responses at each score point (for CR items);
- included appropriate and clear graphics/art/photos that were relevant to the item and were accessible to all testing populations;
- was free of ethnic, gender, political, and religious bias;
- avoided construct-irrelevant content that may unfairly advantage or disadvantage any student subgroup; and
- considered access issues at the time of item writing (e.g., determine how students with visual disabilities would access items with needed visuals/graphics/animation).

The committee made one of three recommendations on every item based on the content and bias review: “Accept,” “Accept with Edits,” or “Reject.”

Following the CMAS (including CSLA) educator meetings, CDE, Pearson, and Tri-Lin assessment specialists reviewed committee comments, reconciled proposed edits, and finalized item outcomes. ABBI was updated to reflect the edits and outcomes. The approved items and passages were then made ready for inclusion on 2019 forms as embedded field test items.

Data Review

After developments of the items, selected items were placed on the operational assessments in embedded field-test positions. The goal of the field test was to allow for the evaluation of the quality of the items through a review of item performance data to determine if the functioning of the items supported their inclusion in the item pool used for operational forms construction.

Following the administration of items in a field-test environment, a committee of educators was convened to review them along with student performance data. Separate data review committees were convened for CMAS mathematics, ELA, and the accommodated CSLA items. Data review committee members were provided item images and metadata, along with classical statistics and differential item functioning (DIF) statistics.

Classical statistics included item means, item–total correlations, and distribution of responses across answer options or score points, depending on item type. Items were flagged based on several statistical criteria (e.g., very low or very high item mean, low item–total correlation, few or no students achieving a certain score point, etc.), and flagged items were taken to data review.

DIF analyses for CMAS items were conducted on various subgroups (gender, ethnicity, free and reduced lunch, IEP, and ELs) using Mantel–Haenszel Delta DIF statistics (Dorans & Holland, 1992). The same analysis methods were used for CSLA items, but the DIF analyses are conducted by gender only, due to the population of students taking the form. Classification rules derived from National Assessment of Educational Progress (NAEP) guidelines (Allen, Carlson, & Zelenak, 1999) were used to classify items as having either negligible, moderate, or significant DIF. Items that are classified as moderate or significant DIF are taken to data review.

During the data review meeting, educators were trained to interpret the statistical information and judge the appropriateness of the items presented for data review. The committee members used the data as a tool to direct them toward potential flaws in an item and discussed whether there were construct-irrelevant reasons for a data flag. A data flag, by itself, was not the sole reason an item would be rejected. Committee members were instructed that their final judgments about the appropriateness or fairness of an item for any individuals and subgroups encompassed by the data flag should be based on their expertise with their content area and experience as Colorado educators. Committee members reviewed each item and made a recommendation as to whether to “accept” or “reject” it. An accepted item meant that the educators, through their varying expertise, determined that there was not a construct-irrelevant reason for the data flag within the item. A rejected item indicated that the educators determined there was a construct-irrelevant reason for the data flag. Construct irrelevant reasons for data flags could include issues such as language that is above grade-level or content that is biased against a particular group. Construct relevant reasons for data flags could be simply difficult content that is part of the standards or distractors that reflect a very common misunderstanding of the concept covered by the item. Following the meeting and CDE determinations, ABBI was updated by moving accepted items into “Ready for Operational” status.

Item Banking System

Pearson’s proprietary software, ABBI (Assessment Banking and Building solutions for Interoperable assessments), was used to support the item and test development process from initial content authoring through the content review cycles. ABBI was the authoritative source for all content, data, and functionality for all CMAS system components.

ABBI served as the repository where the item bank was housed, item revisions were catalogued, and items and item metadata were uploaded and revised by assessment specialists. Items could be moved into various statuses, each representing a step in the item development process. The items and associated stimuli were tracked, and revisions were recorded from creation through retirement in a secure environment.

Custom development reports can be generated out of ABBI. This feature allows content assessment specialists (and clients who have access to ABBI) to generate Excel reports that capture metadata (e.g., unique item number, evidence statement, task type, cognitive complexity, associated stimulus, item status, item statistics, and comments) useful for analyzing the item bank. ABBI is the source of reference for how and when changes to the item and the metadata have been implemented.

CHAPTER 3: TEST CONSTRUCTION

Pearson is responsible for the implementation and monitoring of all phases of the test construction process. Test forms are constructed through an iterative process between Pearson and Measurement Incorporated staff for CMAS mathematics and ELA, and Pearson and Tri-Lin staff for CSLA. Once test forms are constructed, CDE then reviews the forms, provides feedback, and gives final approval as described below.

When building test forms, Pearson, Measurement Incorporated, or Tri-Lin assessment specialists select a set of operational items in accordance with the test blueprint and test construction specifications (see Figures 1 through 4 for test blueprints). Items selected for operational use must meet the blueprint and should include a variety of topics and contexts with specified psychometric targets.

The following guidelines for CMAS mathematics, ELA, and CSLA were used during 2019 form construction:

- adherence to established test blueprints and test construction specification targets based on 2018 forms
    - exact match to blueprint for subclaims
    - same distribution of cognitive complexity
    - same percentage of TEIs
- review of the item statistics and adherence to the statistical criteria found in the test construction specifications
    - evaluation of item means, point biserial correlations, and score point distributions
    - evaluation of IRT item parameter estimates: a, b, d1, d2, d3, and d4
    - evaluation of fit statistics
    - mirroring of 2018 test characteristic curves and conditional standard errors of measurement curves
- balance in the representation of gender, ethnicity, geographic regions, and relevant demographic factors
- thorough review of individual items to establish the content within items is up to date and relevant
- selection of items with various stimulus types throughout the test form to enhance the test-taker experience by providing variation in the appearance of item types presented

- efficient and deliberate use of varied content representative of the knowledge and skills in the ESs
- review of full form, including field-test items, for instances of clueing and/or content overlap

After the initial operational item pull is complete, the test form is reviewed by Pearson, Measurement Incorporated, and Tri-Lin assessment specialists. The assessment specialists verify that the form meets the blueprint and test construction specifications (i.e., the required ES coverage, domain and subclaim coverage, cognitive complexity allocation, task type). The form is then presented to a Pearson psychometrician for analysis, and the psychometrician verifies that the form falls within the established psychometric and blueprint parameters. The psychometric lead also identifies the anchor item set within each operational form. Chapter 8 of this report provides more details about the anchor sets.

Once the form is vetted internally, the form is presented to CDE for review. If needed, the Pearson, Measurement Incorporated, and Tri-Lin assessment specialists, Pearson psychometricians, and CDE collaborate to finalize the form. This can be an iterative process, with the end result being CDE's approval of the form.

After the operational form is approved, field-test items are selected from the item bank. Items chosen for field-testing are placed on a form in a designated section and sequence. Pearson and Tri-Lin assessment specialists assemble field-test sets of items so that they comprise the appropriate distribution of standards, subclaims, task types, topic coverage, cognitive levels, and key distributions to meet the required item refresh rates in following years.

Online Forms

The majority of students take the CMAS mathematics and ELA assessments online. Using this format allows not only for the use of innovative item types but also for additional accessibility options and accommodations as described in Chapter 4 (e.g., text-to-speech).

Accommodated Test Forms

Accommodated test forms for CMAS mathematics are available for both the online and paper-based forms. For online forms, text-to-speech and color contrast are available in English and Spanish. For paper forms, the various options are described below. In addition, oral scripts in both English and Spanish are available for online and paper forms. English oral scripts are also available for local translation into languages other than Spanish.

Accommodated test forms for CMAS ELA are available for both the online and paper-based forms. For online forms, text-to-speech and color contrast are available in English. For paper forms, the various options are described below. In addition, English oral scripts are available for online and paper forms.

Paper

Paper-based versions of the CMAS mathematics and ELA assessments are published and are available if needed for an accommodation or for schools that choose not to test online, as allowed by state law. A Spanish transadaptation is also available on paper for CMAS mathematics.

As discussed in the previous chapter, the paper form is parallel to the online form, meaning paper and online forms of the 2019 CMAS mathematics and ELA assessments included the same operational items. Parallel paper-based items are developed for TEIs. In some cases, this is achieved with traditional SR items. In other cases, it requires an item that must be human-scored. For example, a drag-and-drop item may be converted to an item in which the student must draw a line between various draggers and drop bays. During equating, the statistics of the TEI are compared to the paper-based version to confirm equivalence.

CMAS CSLA is the accommodated version of CMAS ELA for eligible Spanish-speaking students in grades 3 and 4 and is administered on paper.

Braille

After approval of the CMAS mathematics and ELA paper test materials, a braille version of the assessments is created according to the process outlined below:

1. Pearson posts final test forms as PDFs to subcontractors (National Braille Press (NBP) for ELA and Region 4 for mathematics).
2. Subcontractor reviews the items for brailleability. During this review, translation concerns for text and graphics are noted.
3. Brailleability review report is provided to Pearson.
4. Pearson and CDE review and provide solutions for brailleability concerns.
5. Subcontractor translates the test form into braille.
6. The braille form is proofread twice by a braille proofreader who is National Library Service certified or a certified transcriber.
7. Edits are made based on the proofreader’s feedback.
8. The braille form is sent to Pearson.

9. The braille form is reviewed by a committee of Pearson staff, CDE staff, subcontractor staff, and Teachers of the Visually Impaired (TVI) who are certified in braille.

10. Notes from the committee review are verified by CDE staff and are sent to subcontractor for updates to the braille form.

11. The braille form is finalized and printed.

Large Print

Large print versions of the CMAS mathematics, ELA, and CSLA assessments are also created. The large print versions are a 50% enlargement of the regular paper form and are printed on 14” × 18” paper. When needed, the large print version includes a Visual Description booklet, which contains a description of artwork (maps, photographs) for which it may be difficult for a student with visual impairments to see the subtleties within the art. CDE reviews the paper form and identifies what pieces of art need to be described in the Visual Description Test Booklet.

CHAPTER 4: TEST ADMINISTRATION PROCEDURES

This chapter of the report provides information related to the CMAS (including CSLA) administration procedures. Prior to the administration of the assessments, districts, schools, and teachers (Test Administrators) were to ensure that their students and systems were prepared for the assessments. Such information was communicated to the appropriate individuals via manuals and in-person and recorded trainings as described below.

Manuals

Several manuals were created to aid with the CMAS administration, described in the following sections.

CMAS Test Administrator Manual for Computer-Based Testing and the CMAS Test Administrator Manual for Paper-Based Testing

These manuals describe the procedures Test Administrators were to follow when administering the paper and online CMAS assessments. Prior to administering the assessments, Test Administrators were to read these manuals carefully. Test administration policies and procedures were to be followed as written so that all testing conditions were uniform statewide. The guidelines and test administration scripts in these manuals were provided to ensure that every student in Colorado received the same standard directions during the administration of the test.

PearsonAccess^{next} Online User Guide

This guide provides guidance for District Assessment Coordinators (DACs), School Assessment Coordinators (SACs), District Technology Coordinators (DTCs), Test Administrators, and Student Enrollment/Sensitive Data personnel who utilize PearsonAccess^{next}.

CMAS and CoAlt Procedures Manual

This manual provides instructions for the coordination of the CMAS assessments. Instructions include the protocols that all school staff were to follow related to test security, test administration, and providing accommodations to students with disabilities and English learners and accessibility features to all students. The manual also includes the tasks that were to be completed by DACs, SACs, DTCs, and data specialists before, during, and after test administration.

Administration Training

Administration training is intended to make sure all individuals involved in CMAS assessment activities at the school and district levels are prepared to follow administration processes and procedures with fidelity, as well as support adherence to security procedures. Fidelity to standardized test administration processes and procedures helps to ensure the comparability of resulting scores and accurate interpretation of results. Thorough in-person regional trainings were conducted by CDE and Pearson personnel across the state. CDE and Pearson presented trainings to the DACs that contained information regarding proper procedures for administration, security requirements, receiving and returning materials to Pearson, and the use of PearsonAccess^{next} with TestNav 8. Additionally, recorded versions of the live trainings were posted on the CDE Assessment Unit website. Administration training materials, including slide decks, manuals, and how-to guides were also available on the CDE Assessment Unit website for training SACs and Test Administrators. After CDE trained DACs, the DACs trained School Assessment Coordinators, Test Administrators, and any other individuals within the district who planned to participate in the 2019 administration.

Pearson customer service center staff were also trained to answer questions thoroughly and knowledgeably about the administration, and to escalate inquiries as necessary. A knowledge base of commonly asked questions was created to ensure accurate and consistent responses to school and district personnel. The knowledge base was created by the CDE Assessment Unit and Pearson Program Team based on information covered in the training materials and manuals. Revisions and additions were made to the knowledge base as needed. CDE met with Pearson daily during the administration window to review questions from districts and ensure that appropriate answers were provided. Policy questions received by the Pearson customer service center were referred to the Department.

On-site Preparation

Districts were instructed in site readiness preparations, TestNav, proctor caching, and use of the SystemCheck tool to configure their testing technology environments and evaluate their configuration for district readiness.

Districts were also provided with tools and resources to test their environment readiness status. Issues identified from site readiness evaluations were assessed by Pearson and CDE and appropriate corrective actions were developed and communicated to affected districts.

Accessibility and Accommodations

Accessibility features and accommodations provided in 2019 were consistent with those offered to students in 2018. Accessibility was considered from the beginning of the test development process and was inherent within the CMAS assessment and administration. For example, the CMAS mathematics and ELA online test engine, TestNav 8, includes tools and accessibility features, such as a text highlighter, that were made available to all students to increase the accessibility of the assessments. Also included was the text-to-speech accessibility feature for mathematics, which allowed for text to be read to students by means of the embedded software audio feature. Although the accessibility features of text-to-speech and online color contrast were available to all students, only those who needed text-to-speech or color contrast were assigned to these accessibility features in advance of testing. Similarly, CSLA was designed to be linguistically accessible for eligible Spanish-speaking students.

Beyond the tools and accessibility features, assessment accommodations were available to the population of students who had IEP, 504, or EL plans. Accommodations are intended to provide a student with an opportunity to access the assessment without impacting the construct measured by the assessment. Accommodations can be adjustments to the test presentation, materials, environment, or response mode of the student and are based on individual student need. Accommodations should not provide an unfair advantage to any student. Providing an accommodation for the sole purpose of increasing test scores is not ethical.

Accommodations must be documented and used regularly during classroom instruction and assessments prior to the assessment window to ensure the student can successfully use the accommodation. Although accommodations are used for classroom instruction and assessments, some may not be appropriate for use on statewide assessments. As a result, it is important that educators become familiar with the state assessment policies about the appropriate use of accommodations and that districts have a plan in place to ensure and monitor the appropriate use of accommodations. Certain accommodations are allowed only in special cases with CDE approval, due to being an inherent violation of the intended construct (e.g., auditory presentation for ELA and CLSA, which are intended to measure reading ability).

Some of the available accommodations for CMAS include CSLA in place of ELA (other linguistic accommodations do not apply as CSLA is the linguistic accommodation), English oral scripts (mathematics and with CDE approval for ELA), Spanish oral scripts (mathematics and with CDE approval for CSLA), oral scripts for signed presentation and local translation into languages other than English and Spanish, braille forms, large print forms, assistive technology forms for screen readers, and Spanish forms with and without text-to-speech for mathematics.

Live webinar accommodations and accessibility features training was conducted by CDE for district level personnel. The intent of this training was to ensure all individuals providing these supports across the state follow the procedures associated with each accommodation and accessibility feature. Providing accessibility features and accommodations in a standardized manner helps to ensure the comparability of resulting scores and accurate interpretation of results. A recorded version of the live training, slide decks, and procedural information (*Section 6.0* of the *CMAS and CoAlt Procedures Manual*) were available on the CDE Assessment Unit website for training SACs and Test Administrators.

Test Security

Procedures described in this section were put in place to enhance the likelihood that security was maintained before, during, and after the assessment administration. Materials used during the paper administration of the assessment were to be kept in locked storage locations when not under the direct supervision of Pearson or approved testing coordinators and administrators. All district and school personnel involved in the assessment administration were required to participate in annual local training on the CMAS assessment. DACs were responsible for overseeing training for the district, including verifying that the DTC and SACs were trained. SACs were responsible for ensuring that Test Administrators, Test Examiners, and all individuals involved in test administration at the school level were trained and subsequently acted in accordance with all security requirements. A chain of custody plan for materials was required to be written and implemented to ensure materials were securely distributed from DACs to SACs to Test Administrators/Test Examiners and securely returned from Test Administrators/Test Examiners to SACs and then to DACs. SACs were required to distribute materials to and collect materials from Test Administrators/Test Examiners each day of testing, and securely store and deliver materials to DACs after testing was completed in accordance with the instructions in the 2019 CMAS/CoAlt Procedures Manual.

All individuals involved in the administration of the assessments were required to sign a security agreement prior to handling test materials, which required them to follow all procedures set forth in the aforementioned manuals and prevented them from divulging the contents of the assessment, copying any part of the assessment, reviewing test questions with the students, allowing students to remove test materials from the room where testing was to take place, or interfering with the independent work of any student taking the assessment. During online testing, all computer functions not necessary to complete the test were disabled, and access was restricted to disallow activities in all applications outside the testing program.

The PearsonAccess^{next} online administration platform used during the administration included permissions-based user role access to all information within the system including accessing student information, setting up and delivering test sessions, administering tests, and accessing reports. Access to online assessments was tightly controlled before, during and after test administration, requiring a login ID and password to enter the system for each unit. Test content was locked and could not be accessed by students or district/school level user after the students submitted their answers. Each unit of the paper test required students to break the unit seal before accessing the test content. To enhance security during test administration, assessment forms were spiraled at the student level, decreasing the likelihood that a student would be working on the same items as their peers at the same time.

After all test sessions were completed at a school, used and unused materials were required to be securely stored and returned to the DAC by the district deadline for shipment to Pearson. DACs were required to report any missing test materials or test irregularities and to complete the appropriate documentation.

CHAPTER 5: SCORING THE ASSESSMENT

The CMAS assessments contain various item types. CMAS ELA assessments contain selected response (SR); technology enhanced (TE), including parallel paper-based versions; and prose constructed-response (PCR) items. Since it is administered on paper, CSLA forms only contain SR and PCR items. CMAS mathematics assessments contain SR, TE and constructed response (CR) items. SR and TE items are machine-scored, with point values varying by item type and assessment. CMAS mathematics CR items are hand scored. The PCR items are scored on two trait dimensions using a combination of human and automated scoring. The holistic rubrics used to score the CMAS ELA and CSLA PCR items can be found in Appendix A. For CMAS ELA, a portion of PCR item responses are scored using an automated scoring engine that has been trained with human scored responses.

To maintain comparability with the scoring prior to 2019, scoring rules for SR and TE machine scored items (e.g., multiple choice, drag-and-drop, etc.) as well as CR items (i.e., used prior years' rubrics, anchor papers, rules and scoring methods with the exception of paper-converted technology-enhanced items) were preserved from previous years.

Pearson's Performance Scoring team implemented the CR and human PCR scoring process for CMAS mathematics and ELA, including CSLA. The CR scoring process is described below for operational scoring and field test scoring. The rangefinding process and the major components of the quality assurance system including backreading, calibration, and validity papers are also addressed.

As discussed in previous chapters, the 2019 CMAS assessments contained operational items developed exclusively by Colorado as well as previously used operational items developed as part of a multi-state consortium. This chapter deals primarily with scoring processes implemented for the operational items developed exclusively by Colorado. For details about scoring processes implemented for previously used operational items, see the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018*.

Machine Scoring

To maintain comparability with the scoring prior to 2019, scoring rules and processes for operational SR and TE machine scored items (e.g., multiple choice, drag-and-drop, etc.) were preserved from previous years.

Machine scored items included key-based items and rule-based items. Key-based items tended to be a version of multiple choice and multiple select (students select more than one correct answer). Rule-based items were machine scored technology-enhanced items.

Initial scoring expectations were developed during item development and were included as part of the item review process. The scoring rules and correct responses were included in the items' XML coding.

For all items that were machine scored, prior to scoring, key checks were completed to verify that the machine was correctly identifying correct and incorrect responses. If there was a discrepancy in the scoring, content experts reviewed the item and adjustments were made as needed. During testing, actual distribution of scores was compared to expected distribution. Further evaluation was completed if a discrepancy was identified.

Human Scoring

Operational Scoring

Human scored operational items utilized the same scorer credentials and qualifications; rubrics; training responses; qualification responses and processes; validity responses and reliability processes and statistics as in prior years.

Each operational assessment was scored using either a Distributed or Regional Scoring model depending upon content area. Items on the CSLA form and paper-based TEIs were regionally scored while scoring for all other human-scored items was completed through distributed scoring. Scoring includes several components that together provided a comprehensive performance scoring model.

- All scorers were required to pass a background check and sign a nondisclosure agreement agreeing to adhere to all security and confidentiality requirements.

- All scorers had at a minimum, a 4-year degree. Scorers were assigned to content areas based on their educational backgrounds, related fields of work and their demonstrated knowledge in the content area.

- Scorers of items appearing on the CSLA forms had to be proficient in written Spanish and English languages.

- Scorers were trained using comprehensive training materials developed by scoring experts. These materials relied on student responses scored at the rangefinding meetings by educators from Colorado. Prior to qualifying for an item, scorers reviewed an online training module that included an overview of scoring; information specific to the item, like the prompt and rubric; and anchor sets. Scorers then scored multiple practice sets prior to attempting qualification. After successful qualification, scorers began scoring the item.

    - For CSLA items, training was led by a Pearson scoring director who presented item-specific materials, including the prompt and rubric. The scoring team then received training on anchor sets prior to moving into the online portion of training where scorers applied scores on multiple practice sets within the electronic scoring system. After each practice set, the scoring director reviewed the practice set results with the scorers prior to scorers taking qualification sets. After successful qualification, scorers began scoring the item.

- Scorers had to pass a qualifying test for the item types that they scored. Qualification sets were designed to test scorer accuracy across the range of score points for a given item.

- Student responses were converted to electronic images at Pearson facilities. They were then transmitted for computer-based scoring.

- Distributed scorers were located across the United States and worked from their homes. Their computers were set up for image-based scoring. A comprehensive set of scoring and monitoring tools were integrated into the scoring system. In addition to the systemic tools, content supervisory staff were available by phone to help answer any training or scoring related questions that may arise. With distributed scoring, scorers were able to score 7 days per week with extended evening hours.

- Regional scorers were located within a physical scoring location site. As with distributed scoring, regional scoring also utilized a comprehensive set of scoring and monitoring tools integrated into the scoring system. In addition to the systemic tools, content supervisory staff were physically on site to help answer any training or scoring related questions that arose. Unlike distributed scoring, regional scoring was typically only completed Monday through Friday during normal business hours. Regional scorers were used for CSLA forms and paper-based TEIs.

- Additional security procedures were in place for distributed scoring. Data were securely transmitted through HTTPS and SSL technology using secure protocols for system authentication. Student responses were randomly routed through the scoring platform preventing scorer knowledge of student information, unless a student self-identified in the response. Scorers agreed not to use shared, institutional, or public computers to score and also not to save student responses or test materials. Scorer printing capabilities of materials, such as anchor papers, were only approved for printing after they had undergone and passed a personally identifiable information review by CDE. Scorers agreed to securely destroy or return to Pearson printed materials at the conclusion of scoring.

Pearson’s processes and tools provided a replicable quality system that strengthened consistency across projects and locations within Pearson’s Scoring Services operations. Pearson’s Scoring Services team used a comprehensive system for continually monitoring and maintaining the accuracy of scoring on both group and individual levels. This system included daily analysis of a comprehensive set of statistical monitoring reports, as well as regular “backreading” of scorers. Reliability statistics were monitored during scoring, and interventions were applied if a scorer or item was not meeting minimum requirements. A detailed description of these measures is included in Chapter 9.

Field Test Scoring

Embedded field test scoring was completed using regional scorers. Regional field test scoring took place in San Antonio, TX, Austin, TX, Virginia Beach, VA, Mesa, AZ, and Iowa City, IA, for ELA; San Antonio, TX, for CSLA; and San Antonio, TX, Austin, TX, Columbus, OH, and Mesa, AZ, for mathematics. All scorers were required to have a four-year college degree.

Field test scorers received stand-up training led by a Pearson scoring director who presented item-specific materials, including the prompt and rubric. Scorers then reviewed the anchor sets in a group setting prior to scoring practice sets on paper.

Rangefinding

Constructed-response (CR) items were scored using rubrics. For mathematics, rubrics were generated for each unique item, while ELA used holistic rubrics for each item type. Rubrics were finalized at rangefinding and were maintained, along with the training materials for each item, by Pearson's Scoring Services group.

Rangefinding meetings were held following the administration in which an item was field tested. The purpose of rangefinding was to define the range of performance levels within the score points of the rubrics using student responses. Each rangefinding committee included Pearson's Scoring Services and content staff, state content representatives, and educators with relevant grade-level and content expertise and experience with special populations. Participants created consensus scores for a sample set of student responses that were subsequently used to develop effective training materials for scoring of CR items.

Pearson's scoring directors constructed one rangefinding set per item, which included approximately 30 responses. For multi-point items, pre-constructed sets with additional responses were brought to the meeting. Responses included in these sets represented the full spectrum of scores to the greatest extent possible. For each item, the responses were ordered based on estimated score from high-scoring to low-scoring; however, actual scores were not revealed to committee members. Each set included responses clearly earning each available score point for each type of question. The set also included samples of responses that may have been challenging to score (i.e., the score points earned were not necessarily clear).

Following an introductory session presented by a member of the Scoring Services group, the rangefinding committee was divided into several break-out groups based on educator expertise. Each group was assigned a range of field-test items to be reviewed, following the process outlined below:

1. The Scoring Director introduced each item. The committee reviewed the item and corresponding rubric.
2. The committee read student responses—individually or as a group—and then discussed and decided the most appropriate score for each response.
3. The Scoring Director recorded committee members' comments as well as the final consensus score for each student response. Consensus was reached when a majority of committee members agreed upon a particular score point for a response and all members agreed to accept the score of the majority.

4. A designated committee member recorded consensus scores. After reviewing responses for each item, the committee member compared his or her notes with those kept by the Scoring Director and provided sign-off to indicate agreement with the recorded scores.

Following the rangefinding meetings, Scoring Services personnel created training material with an anchor set, which was used for initial training (up to 15 responses), and a full practice set (up to 10 responses). For ELA, two anchor sets were used per item, one for content and one for conventions. Each CR item was then scored with the associated training materials.

Backreading

Backreading is the method of immediately monitoring a scorer's performance and is, therefore, an important tool for Pearson's scoring supervisors. Backreading was performed in conjunction with the statistics provided by reader performance reports and as indicated by scoring directors, allowing scoring supervisors to target particular readers and areas of concern. Scorers showing low inter-rater agreement or those showing anomalous frequency distributions were given immediate, constructive feedback and monitored closely until sufficient improvement was demonstrated. Scorers who demonstrated through their agreement rates and frequency distributions that they were scoring accurately would continue to be spot-checked as an added confirmation of their accuracy. An explanation of rater agreement statistics can be found in Chapter 9, and rater agreement statistics for the spring 2019 administration can be found in Part II of this report. The agreement rate requirements are as follows:

Math, ELA (including CSLA), Science, Social Studies:

- 1-point item: 90% perfect and 95% perfect plus adjacent agreement
- 2-point item: 90% perfect and 95% perfect plus adjacent agreement
- 3-point item: 80% perfect and 95% perfect plus adjacent agreement
- 4-point item: 70% perfect and 95% perfect plus adjacent agreement
- 5+-point item: 65% perfect and 95% perfect plus adjacent agreement

Calibration

Calibration sets are responses selected as examples that help clarify particular scoring issues, define more clearly the lines between certain score points, and reinforce the scoring guidelines as presented in the original training sets. They can be applied to groups, a subset of groups, or individual scorers, as needed. These sets are used to proactively promote accuracy be exploring project-specific issues, score boundaries, or types of responses that are particularly challenging to score consistently. Scoring directors administer calibration sets as needed, particularly for more difficult items.

Validity Papers

Validity is a quality monitoring tool used during scoring. Validity papers are student responses chosen by Pearson scoring directors to measure accuracy of a scorer when applying the scoring rubric. Validity papers are blind to scorers, which means a scorer is not aware when they are scoring a validity paper. Scoring directors may choose to include an annotation with a validity paper so that a scorer will receive immediate feedback if a validity paper is scored incorrectly. This is known as validity as review. Validity statistics are monitored by scoring directors throughout the life of a scoring project.

Automated Scoring

Consistent with prior years' scoring, automated scoring performed by Pearson's Intelligent Essay Assessor (IEA) was the default option for scoring the CMAS ELA assessments' online prose constructed-response (PCR) tasks. Of the fifteen operational PCRs in 2019, eight had an automated scoring model based on training from prior operational years, one was trained based on 2018 field test data, and the remaining six were scored by human scorers.

Items that used automated scoring were also checked for quality using second scores by human scorers. Ten percent of responses were randomly selected and given a second reliability score to provide data for evaluating the consistency of scoring. Some responses were not scored by the engine at all and received a first human score based on Smart Routing of particular score points. This procedure is described in more detail below.

Continuous flow

Continuous Flow scoring results in an integrated connection between human scoring and automated scoring. It refers to a system of scoring in which either an automated score, a human score, or both could be assigned based on predetermined criteria.

For IEA training for operational items completed in prior years, continuous flow scoring facilitated the training of IEA using human scores assigned to operational online data collected early in the administration in cases where that was necessary. Once IEA obtained sufficient data to train and meet reliability criteria targets, it could be "turned on" and becomes the primary source of scoring (although human scoring continued for the 10 percent reliability sample and other responses that were routed accordingly).

The engine for one operational item in 2019 was trained based on field test data from 2018, using all the available responses. Two-thirds of the responses were used to train the engine, and one-third were held out to evaluate performance.

Smart routing

The use of "smart routing" during operational scoring increases the quality of automated scoring by routing responses that are more likely to disagree with a human score to receive an additional human score.

When human scorers read a response, they typically apply integer scores based on a scoring rubric. For example, when there is strong agreement between two independent human scorers, they might both assign a score of 3, such that the average score over both raters is also a 3 (i.e., (3+3)/2 = 3). IEA simulates this behavior, but because its scores come from an artificial intelligence algorithm, it generates continuous (i.e., decimal-valued) scores. In the previous example, the IEA score might be a 2.9 or 3.1. Similarly, if the human scorers disagreed on a response and scored it as a 3 and a 4, for example, IEA would likely provide a score between 3 and 4 (e.g., 3.4 or 3.6). This continuous IEA score needs to be rounded to an integer score for reporting (i.e., a 3 or a 4, depending on rounding rules, in this example). Smart routing involves routing for additional human review those responses where the IEA score tends to disagree with human scores. Because the cases that result from "in between" scores are based on modeling human scores, it follows that human scores may be less certain as well. Therefore, responses are more likely to be double-scored and resolved if the IEA and human scores are non-adjacent.

Smart routing was utilized as needed to achieve targeted quality metrics (e.g., validity agreement or agreement with human scorers). Smart routing involved the application of the following steps:

1. The continuous IEA score for each of the two trait scores was rounded to the nearest score interval of 0.2, starting from zero. For example, IEA scores between 0 and 0.1 were rounded to an interval score of 0, scores between 0.1 and 0.3 were rounded to an interval score of 0.2, scores between 0.3 and 0.5 were rounded to an interval score of 0.4, etc.

2. Within each of these intervals, the percentage of exact agreement between IEA integer scores and the human scores was calculated for each trait.

3. For each prompt, agreement rates were evaluated for each interval and for each trait.

4. Responses within intervals for which IEA–human agreement on either trait was below a designated threshold were routed for additional human scoring.

For additional details about the development and training of IEA, see the *PARCC Final Technical Report for 2017 Administration* (Pearson, 2018).

Quality criteria for evaluating automated scoring

For operational scoring, consortium states had previously approved specific quality criteria for evaluating automated scoring at the time IEA was trained. The primary evaluation criteria for IEA was based on responses to validity papers with "known" scores assigned by experts. For each prompt scored, a set of validity papers was used to monitor the human-scoring process over time. Validity papers were seeded into human scoring throughout the administration. The expectation is that IEA can score validity papers at least as accurately as humans can score the papers.

Additional measures of inter-rater agreement for evaluating automated scoring were proposed based on the research literature (Williamson, Xi, & Breyer, 2012). These measures were previously utilized in Pearson's automated scoring research and include Pearson correlation, kappa, quadratic-weighted kappa, exact agreement, and standardized mean difference. These measures are computed between pairs of human scores, as well as between IEA and humans, to evaluate how performance was the same or different. Criteria for evaluating the training of IEA given these measures include the following:

- Pearson correlation between IEA and human scores should be within 0.1 of human–human correlation.
- Kappa between IEA and human scores should be within 0.1 of human–human kappa.
- Quadratic-weighted kappa between IEA and human scores should be within 0.1 of human–human quadratic-weighted kappa.
- Exact agreement rate for IEA and human scores should be within 5.25% of the human–human exact agreement rate. For the one new prompt trained in 2019, the requirement was that the IEA–human exact agreement rate reach at least 80% with smart routing.
- Standardized mean difference between IEA and human scores should be less than 0.15.

The specific criteria for evaluating IEA included both primary and secondary criteria, described below.

Primary criterion. The performance of IEA was evaluated by comparing IEA scores with human scores for the set of validity papers. The primary criterion is stated as follows: *With smart routing applied as needed, IEA agreement is as good as or better than human agreement for each trait score.* For a given prompt, this criterion is operationalized as follows:

1. Determine agreement of the human scores with the validity papers for each trait.
2. Calculated agreement of the IEA scores with the validity papers for each trait.
3. Compare the IEA and human agreement on the validity papers.
4. If the IEA validity agreement is greater than or equal to the human agreement for each trait, IEA can be deployed operationally.

Contingent primary criterion. For many of the prompts trained in 2017, it was not possible to utilize human-scored validity responses in evaluating IEA performance. In these cases, IEA was evaluated based on IEA–human exact agreement for each trait score and compared to agreement based on responses that were double-scored by humans. IEA–human agreement was evaluated on a portion of the data, according to the following steps:

1. Determine exact agreement of the two human scores with each other for each trait.
2. Calculate agreement of the IEA scores with the human scores for each trait.
3. Compare the IEA–human agreement with the human–human agreement.
4. If the IEA–human agreement is within 5.25% of the human–human agreement, IEA can be deployed operationally.

In addition to the overall comparison, the following performance thresholds were targeted in the test data set: 1) at least 65% overall IEA–human agreement, and 2) 50% IEA–human agreement by score point (i.e., conditioned on the human score). These targets went beyond the contingent primary criteria approved by the consortium state leads.

Secondary criteria. The secondary criteria involve comparing agreement indices for IEA–human scoring for various demographic subgroups, and can be stated as follows: *With smart routing applied as needed, IEA–human differences on statistical measures for each trait score are within the Williamson et al. (2012) tolerances for subgroups with at least 50 responses.* IEA–human agreement was evaluated according to the following steps:

1. Determine exact agreement of the two human scores with each other for each trait.
2. Calculate agreement of the IEA scores with the human scores for each trait.
3. Compare the IEA–human agreement with the human–human agreement.
4. For subgroups with at least 50 IEA–human scores and at least 50 human–human scores, compare agreement indices to the following criteria:
    - Pearson correlation between IEA–human should be within 0.1 of human–human.
    - Kappa between IEA–human should be within 0.1 of human–human.
    - Quadratic-weighted kappa between IEA–human should be within 0.1 of human–human.
    - Exact agreement between IEA–human should be within 5.25 percent of human–human.

- Standardized mean difference between IEA–human should be less than ±0.15 (this criterion was applied to subgroups with at least 50 IEA–human scores).

Although it was not expected that these criteria would be met for all subgroups for all prompts, if results of the evaluation between IEA and human scoring for subgroups for any prompt indicated that IEA performance persistently failed on the criteria listed above, consideration would be given to resetting the responses scored by IEA and reverting to human scoring until such time that an alternate IEA model could be established with improved subgroup performance.

In addition to the secondary criteria above, the performance of IEA was also compared with the following targets on the various measures for subgroups with at least 50 responses:

- Pearson correlation between IEA–human should be 0.70 or above.
- Kappa between IEA–human should be 0.40 or above.
- Quadratic-weighted kappa between IEA–human should be 0.70 or above.
- Exact agreement between IEA–human should be 65 percent or above.

Hierarchy of assigned scores for reporting

When multiple scores are assigned for a given response, the following hierarchy determines which score was reported operationally:

- the IEA score is reported if it is the only score assigned
- if an IEA score and a human score are assigned, the human score is reported
- if two human scores are assigned, the first human score is reported
- if a backread score and human and/or IEA scores are assigned, the backread score is reported
- if a resolution score is assigned and an adjudicated score is not assigned, the resolution score is reported (note that if nonadjacent scores are encountered, responses are automatically routed to resolution)
- if an adjudicated score is assigned, it is reported (note that if a resolution score is nonadjacent to the other scores assigned, responses are automatically routed to adjudication)

CHAPTER 6: STANDARD SETTING

To support the interpretation of student results, student performance on the CMAS mathematics, ELA, and CSLA assessments is described in terms of five performance levels. The performance levels and their detailed descriptions are as follows:

> **Level 5: Exceeded expectations**
> Students who demonstrate a distinguished command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They are *academically well prepared* to engage successfully in further studies in this content area.
>
> **Level 4: Met Expectations**
> Students who demonstrate a strong command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They are *academically prepared* to engage successfully in further studies in this content area.
>
> **Level 3: Approached Expectations**
> Students who demonstrate a moderate command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will *likely need additional academic support* to engage successfully in further studies in this content area.
>
> **Level 2: Partially Met Expectations**
> Students who demonstrate a limited command of the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will *need additional academic support* to engage successfully in further studies in this content area.
>
> **Level 1: Did Not Yet Meet Expectations**
> Students who do not yet meet academic expectations for the concepts, skills, and practices embodied by the Colorado Academic Standards assessed at their grade level. They will need extensive academic support to engage successfully in further studies in this content area.

Performance Standards vs. Cut Scores

The performance levels and their descriptions provided above are policy definitions, developed to describe students' performance on the assessment directly in terms of the knowledge, skills, and practices the assessment is intended to measure. Standard setting is the process of translating those policy-driven performance standards into scores on the assessment. The purpose of a standard-setting study is to determine the boundaries—or cut scores—along the score scale that differentiate student performance among those levels (e.g., Cizek, Bunch, & Koons, 2004; Kane, 1994).

CMAS and CSLA Standard Setting

The standards and cut scores used for the CMAS 2019 mathematics and ELA assessments were set in 2015 in collaboration with the PARCC consortium. Details about the standard-setting process can be found in the PARCC *Performance Level Setting Technical Report* (Davis & Moyer, 2015).

CSLA standards were set in 2016 and details are available in the *CSLA Colorado Spanish Language Arts Technical Report* (Colorado Department of Education, 2016).

CHAPTER 7: REPORTING

Several score reports are generated to communicate student performance on the CMAS mathematics, ELA, and CSLA assessments. The reports contain a variety of score types at different levels of the blueprint, as described in this section. For additional details on score reports, see the *CMAS and CoAlt Interpretive Guide 2019* (Colorado Department of Education, 2019), available at http://www.cde.state.co.us/assessment/cmas_coalt_interpretiveguide_2019.

Description of Scores

CMAS mathematics, ELA, and CSLA reports provide information on student performance in terms of scale scores, performance levels, percentile ranks, and percent earned scores.

Scale Scores

A scale score is a conversion of a student's response pattern to a common scale that allows for a numerical comparison between students. Scale scores are particularly useful for comparing test scores over time and creating comparable scores when a test has multiple forms. Students receive scale scores in each of the following areas:

- Overall test
- Reading claim (ELA and CSLA only)

The overall scale for each test ranges from 650 to 850 which was retained from prior years of the CMAS math and ELA assessments. The Reading scale ranges from 110 to 190. The reading scale score is comparable to the scale scores reported in previous years, except that 100 was added to all scores to better differentiate it from a percent earned score. Chapter 8 provides technical details related to scale development.

Performance Levels

Performance levels and performance level descriptors (PLDs) are reported at the overall assessment level. Examinees are classified into performance levels based on their scale score as compared with the cut scores, which were obtained from standard-setting studies (see Chapter 6). Consistent with prior years of the CMAS Math and ELA assessments, there are five performance levels: Did not yet meet expectations, Partially met expectations, Approached expectations, Met expectations, and Exceeded expectations. Students in the top two categories (i.e., Met expectations and Exceeded expectations) are considered to be on track to being college- and career-ready in that content area. The 2019 performance levels, along with the performance level descriptors and the expectations within each performance level, were retained from previous administrations of the assessments. Tables 1 and 2 list the scale score ranges associated with each performance level for each assessment.

Percentile Ranking

Percentile rankings based on the overall scale score are provided on student performance reports to indicate how the student performed compared with other students in the state. For example, a student with a percentile ranking of 70 performed better than 70 percent of students in Colorado.

Percent Earned

To prevent incorrect interpretations and give teachers and parents a metric that is more generally understood, students' performance on the Writing claim (ELA and CSLA) as well as the subclaims in ELA, CSLA, and mathematics are reported as the percentage of points earned within each reporting category. Unlike scale scores, percent of points possible scores cannot be compared across years, because individual items change from year to year and are not constructed to be comparable in difficulty at the claim or subclaim level. In addition, performance on different subclaims cannot be compared within an administration, because the number of items and the difficulty of the items within each subclaim may not be the same.

The percent of points possible score can be compared to aggregated state, district, and school performance on that reporting category. The student performance reports also include an indicator of how students who scored just above the Met Expectations cut score on the overall assessment performed on each category. This indicator gives similar information to the Met Expectations cuts that were used prior to 2018.

Score Reports

Sample CMAS mathematics and ELA student performance reports can be found in Appendix B. CSLA assessments are parallel and comparable to CMAS ELA assessments in scoring and reporting. Therefore, separate CSLA reports are not included (please refer to the CMAS ELA examples). Two types of score reports are provided: student level and aggregate. For a detailed explanation of the information provided in the reports, refer to the *CMAS and CoAlt Interpretive Guide 2019* (Colorado Department of Education, 2019).

Student Performance Reports

Student Performance Reports provide information about the performance of a particular student. The student's scale score(s), associated performance level, percentile ranking, and percent of points possible scores are displayed on a two-page report, along with comparative information related to the student’s school, district, and state performance. In addition, PLDs are provided.

In addition to the electronic versions made available to districts and schools, two copies of Student Performance Reports were printed and shipped to districts for distributing to parents/legal guardians and for maintaining locally.

Aggregate Reports

Several types of aggregate reports are produced for schools and districts.

- Performance Level Summaries
- Content Standards Rosters
- Evidence Statement Analysis Reports
- District Summary of Schools (district level only)

These reports are produced at the school and/or district levels and provide summary information for a given school or district. District and school reports are provided electronically through PearsonAccess Next Published Test Results, and access to the reports is limited to authorized users. Examples of each type of aggregate report and a detailed explanation are provided in the *CMAS and CoAlt Interpretive Guide 2019* (Colorado Department of Education, 2019).

CHAPTER 8: CALIBRATION, EQUATING, AND SCALING

Item Response Theory (IRT) was used to develop, calibrate, equate, and scale the CMAS mathematics, ELA, and CSLA assessments. The two-parameter logistic (2PL) (Birnbaum, 1968) and generalized partial credit (GPC; Muraki, 1992) models were applied to CMAS mathematics and ELA, and the Rasch partial credit model (RPCM) was applied to CSLA. These measurement models are routinely used for forms construction, calibration, scaling and equating, and maintaining and building item banks.

All test analyses, including calibration, scaling, and item–model fit, were accomplished within the IRT framework. For CMAS mathematics and ELA the scales were equated to the previous CMAS (i.e., PARCC) base scale. The calibration of the first operational administration determined the base scale for CSLA.

IRT Models

CMAS Mathematics and ELA

The 2PL and GPC IRT models

The item response functions (IRFs) of the 2PL and GPC IRT models relate examinee ability to the probability of observing a particular item response given the item's characteristics. The item characteristic function (ICF) relates examinee ability to the expected examinee score. The 2PL model (Birmbaum, 1968), uses two item parameters to relate the probability of person *i* correctly answering a dichotomously scored item *j*:

$$P_{ij}(\theta) = \frac{1}{1 + \exp\,[-Da_j(\theta_i - b_j)]}$$

where D is set equal to 1 when defined on the logistic scale, as IRTPRO parameterizes all models. The item discrimination parameter is a_j; and the item difficulty parameter is b_j.

The GPC model (Muraki, 1992) has three item parameters to relate the probability of person *i* responding in the *x*-th category, to a polytomous scored item *j*:

$$P_{ij}(\theta) = \frac{\exp\left[\sum_{v=0}^{x} Da_j\left(\theta - b_j + d_{jv}\right)\right]}{\sum_{k=0}^{M_i} \exp\left[\sum_{v=0}^{k} Da_j\left(\theta - b_j + d_{jv}\right)\right]}\ , x = 0, 1, \dots, M_i$$

where all parameters are as they were before and d_{jv} is the category parameter for category *v* of item *j* and M_i is the maximum score on item *j.*

The graphical representation of the IRF and ICF are the item response curves (IRC) and item characteristic curves (ICC), respectively. For dichotomous items the IRF and ICF are equal, but for polytomous items the IRC and ICF are different.

As an example, consider Figure 5, which depicts a 2PL item that falls at approximately 0.85 on the ability (horizontal) scale. When a person answers an item at the same level as their ability, then that person has a roughly 50% probability of answering the item correctly. Another way of expressing this is that in a group of 100 people, all of whom have an ability of 0.85, about 50% of the people would be expected to answer the item correctly. A person whose ability was above 0.85 would have a higher probability of getting the item right, while a person whose ability is below 0.85 would have a lower probability of getting the item right.

Figure 6 shows IRCs of obtaining a wrong answer or a right answer. The dotted-line curve (*j*=0) shows the probability of getting a score of “0” while the solid-line curve (*j*=1) shows the probability of getting a score of “1.” The point at which the two curves cross indicates the transition point on the ability scale where the most likely response changes from a “0” to a “1.” At this intersection, the probability of answering the item correctly is 50 percent.

Figure 7 shows IRCs of obtaining each score category for a polytomously scored item. The dotted-line curve (*j*=0) shows the probability of getting a score of “0.” Those of very low ability (e.g., below -2) are very likely to be in this category and, in fact, are more likely to be in this category than the other two. Those receiving a “1” (partial credit) tend to fall in the middle range of abilities (the thick, solid-line curve, *j*=1). The final, thin, solid-line curve (*j*=2) represents the probability for those receiving scores of “2” (completely correct). Very high-ability people are more likely to be in this category than in any other, but there are still some of average and low ability who can get full credit for the item.

The points at which lines cross have a similar interpretation as that for dichotomous items. For abilities to the left of (or less than) the point at which the *j*=0 line crosses the *j*=1 line, indicated by the left arrow, the probability is greatest for a “0” response. To the right of (or above) this point, and up to the point at which the *j*=1 and *j*=2 lines cross (marked by the right arrow), the most likely response is a “1”. For abilities to the right of this point, the most likely response is a “2.” Note that the probability of scoring a “1” response (*j*=1) declines in both directions as ability decreases to the low extreme and increases to the high extreme. These points then may be thought of as the difficulties of crossing the *thresholds* between categories.

Item Fit

Item fit is evaluated using Yen’s (1981) Q_1statistic. The Q_1 statistic allows for the evaluation of an item’s IRT model fit to observed student performance. In the calculations of Q_1, the observed and expected (based on the model) frequencies were compared at 10 intervals, deciles, along the scale. Yen’s Q_1fit statistic was computed for each item using the following formula:

$$Q_{1_i} = \sum_{j=1}^{10} \frac{N_{ij}\left(O_{ij}-E_{ij}\right)^2}{E_{ij}(1-E_{ij})},$$

where N_{ij} is the number of students in interval *j* for item *i*, and O_{ij} and E_{ij} are the observed and expected proportions of students in interval *j* for item *i*.

The Q_1statistic was then transformed so that the value could be evaluated using the chi-square distribution:

$$Z_{Q_{1_i}} = \frac{Q_{1_i} - df}{\sqrt{2df}},$$

where *df* is the degree of freedom for the statistic (*df* = 10–the number of parameters estimated; *df* = 7 for SR items in a 3PL model). If $Z_{Q_{1_i}}$is greater than Z_{crit} then the item is flagged for “poor” model fit:

$$Z_{crit} = \frac{N_i * 4}{1500},$$

where $\mathrm{N_i}$ is the sample size.

CSLA

Rasch Partial Credit Model

The RPCM is an extension of the Rasch one-parameter IRT model attributed to Georg Rasch (1966), as extended by Wright and Stone (1979), Masters (1982), and Wright and Masters (1982). The RPCM was selected because of its flexibility in accommodating various item types (i.e., multiple-choice items and items with multiple response categories).

The RPCM is a mathematical measurement model with a single item parameter relating a student’s performance on a given item involving m+1 score categories. The probability of student *n* scoring *x* on *m* steps of item *i* is a function of the student’s proficiency level, θ_n (also referred to as “ability”), and the step difficulties, δ_{ij}, of the *m* steps in question *i* as follows:

$$P_{xni} = \frac{exp \sum_{j=0}^{x} (\theta_n - \delta_{ij})}{\sum_{k=0}^{m_i} exp \sum_{j=0}^{k} (\theta_n - \delta_{ij})} \quad x = 0, 1, \dots m_i$$

Equating and Scaling

Equating of operational test forms involves adjusting for differences in the difficulty of forms, both within and across assessment administrations. Equating makes certain that students taking one form of a test were neither advantaged nor disadvantaged when compared to students taking a different form. Each time a new form is constructed, equating is used to allow scores on the new form to be comparable to scores on the previous form.

If the IRT models fit the data and the model assumptions are met, calibration of test items places both items and students on a scale that is independent of any particular sample of students up to a linear transformation. Equating is used to determine and apply a scale transformation that allows for meaningful comparisons of student performance across different forms or administrations of the test.

Operational Equating and Scaling

Equating is used to place new forms onto the operational base scale. In order to maintain comparability with prior administrations, CMAS mathematics and ELA item parameter estimates for the spring 2019 administration were equated to the established base scale used in 2017. For CSLA, the spring 2019 item parameter estimates were equated to the spring 2016 CSLA base scale.

The spring 2019 CMAS mathematics assessments for grades 3 through 7 were equated to the base scale using an item pre-equating design (e.g., Kolen & Brennan, 2004). All operational items on these forms had been previously calibrated and equated to the base scale. These calibration and equating procedures are described in the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018.* The forms were subsequently scored using these existing item parameters, rather than performing a new calibration and equating. To help ensure the stability of item parameter estimates across administration, items were positioned as closely as possible to their positions when they were calibrated. To ensure that the assumptions of pre-equating were met, a “post-equating check” was performed using anchor sets identified during test construction. The results of this check were compared with the pre-equated results, and are reported in Part II.

The grade 8 mathematics assessment and all ELA (including CSLA) assessments were calibrated and post-equated to the base scale following the procedures described below.

Calibrations

Calibration refers to the estimation of item parameters in the IRT framework, which places items and students on a common scale. In order to obtain item parameter estimates for CMAS mathematics and ELA, the 2PL or GPC model was applied to the items. Dichotomous items were fit to the 2PL model, and polytomous items were fit to the GPC model. IRTPRO (SSI, Inc., 2011) was used for all calibrations, and all operational item parameters were estimated in a single calibration (i.e., concurrent calibration) for each assessment. For CSLA, the RPCM was applied to all items in order to obtain item parameter estimates. All operational items within a grade were also calibrated concurrently. Winsteps (Linacre, 2011) was used for all CSLA calibrations.

For CMAS ELA and CSLA, PCR items were calibrated at the (unweighted) trait score level rather than as aggregated scores. To account for potential local dependence between the two trait scores, the item response matrix for CMAS ELA was modified before operational calibrations. For each PCR item, one of the two trait scores for each student was randomly selected, and the non-selected trait score was then removed from the dataset and treated as missing for calibration. The resulting item response dataset, known as a “Moulder” matrix, contained roughly half as many observations for each PCR trait score as for the non-PCR items. However, the datasets still contained an adequate number of student responses to conduct the calibrations. Due to the small population of students taking the CSLA assessment, trait scores were not removed from the data when conducting calibrations for CSLA.

CMAS Mathematics (grade 8 only) and ELA

Equating design. A common items approach was used for equating operational forms for the CMAS mathematics (grade 8 only) and ELA assessments. Forms from adjacent administrations contain a set of items that are the same across the two administrations. This set of items represents the blueprint in terms of content and represents roughly 30% of a full form.

Consistency of constructed-response scoring check. The CMAS assessments include a high percentage of constructed-response (CR) items and therefore, to be more reflective of the construct being measured, the anchor sets include CR items. For accurate equating, it is important that the items in the anchor sets be consistently scored across administrations. With selected-response (SR) items, scoring is exactly the same each time the item is administered (e.g., ‘A’ is always scored as the correct answer) such that changes in item performance across administrations can be solely attributed to changes in student performance. With CR, scoring is done by human raters, so it is important that scoring be monitored both within an administration and across administrations to maintain consistent scoring throughout. Such procedures were in place, including consistency in training and the use of validity papers throughout scoring. As an additional check, the consistency of the CR scoring was examined prior to equating via the rescoring of a subset of the previous year’s papers to remove any items that exhibited statistical drift in scoring characteristics so that the accuracy of the equating was not jeopardized. If a CR item appeared to lack consistency across the administrations, considerations were given to removing the item from the anchor set.

Stability check. The item parameter stability check for the anchor items was conducted using classical item analyses, scatter plots of item parameter estimates, and ICC comparison. For the ICC comparison, old and new ICCs were compared using the *z*-score approach based on D^2 (Wells, Hambleton, Kirkpatrick, & Meng, 2014) as outlined below:

1. Obtain the theoretically weighted estimated posterior theta distribution using 31 quadrature points (-5 to 5).
2. Compute the slope and intercept constants using the Stocking & Lord method with all anchor items in the linking set.
3. Place the original anchor item parameter estimates onto the baseline scale by applying the constants obtained in Step 2.

4. For each anchor item, calculate D^2 between the ICCs based on old (x) and new (y) parameters at each point in this theta distribution:

   $$D_i^2 = \sum^{k} \left[P_{ix}(\theta_k) - P_{iy}(\theta_k)\right]^2 \bullet g(\theta_k)$$

   where i = item, x = old form, y = new form, k = theta quadrature point, and g = theoretically weighted posterior theta distribution.

5. Compute the mean and standard deviation of the D^2 values.

6. Flag the items with a D^2 more than 2 standard deviations above the mean.

Final anchor sets. Items flagged from the stability check and consistency of constructed-response scoring check were examined, and consideration was given to the impact of flagged item(s) on the content representativeness of the resulting anchor set. A flag alone was not the sole criteria for removing an item from the linking set. It was important to also make sure that the remaining anchor set continued to be representative of the overall content and structure of the test.

Equating method. Using the item parameter estimates for the anchor set from the PARCC bank and the current administration, the computer program STUIRT (Kim & Kolen, 2004) was used to obtain the transformation constants to place the current administration's items on the operational scale using the Stocking & Lord (1983) method. The scale transformation constants, slope A and intercept B, were applied to the item parameter estimates to place the new test items (new, N) on the operational scale (old, O) (Kolen & Brennan, 2004), as follows:

$$\alpha_{jO} = \alpha_{jN}/A$$

$$b_{jO} = A * b_{jN} + B$$

$$d_{jvO} = A * d_{jvN}$$

Paper forms. Online and paper items were developed to be parallel to the online items. Operational paper items deemed identical to operational online items were assumed to have the same item parameter estimates. Paper items were fixed to their online counterparts' item parameter estimates. This process produced item parameter estimates for all paper items.

CSLA

Equating design. A common items approach was used for equating the CSLA operational forms. Forms from adjacent administrations contained a set of items that were the same across the two administrations (i.e., anchor items). Anchor items were operational items that were already equated to the base scale. The anchor items were placed in the same positions across all test forms within a grade, and anchored the scale between the new test form and the base scale. This set of items represents the blueprint in terms of content and represents roughly 30% of a full form.

Stability check. The stability check for the CSLA anchor items was conducted using classical item analysis, scatter plots of item difficulty, and displacement estimates from Winsteps. Items were flagged if the absolute value of the displacement estimate was greater than or equal to 0.30.

Final anchor sets. Items flagged from the stability check were examined, and consideration was given to the impact of flagged item(s) on the content representativeness of the resulting anchor set. A flag alone was not the sole criteria for removing an item from the linking set. It was important to also make sure that the remaining anchor set continues to be representative of the overall content and structure of the test.

Equating method. To obtain equated Rasch parameter estimates for the spring 2019 assessments, anchor item parameter estimates for each grade-level assessment were fixed to their previously equated item parameter estimates before calibrating the remaining non-anchor operational items on that assessment. This method placed the non-anchor operational items on the same scale as the anchor items.

Comparability of Online and Paper Forms for CMAS Mathematics and ELA

The scale score distributions for students taking online and paper assessments were examined using a matched samples approach to investigate the extent to which the online and paper forms produced comparable scores. Multiple variables were used for determining the matched groups to result in "equal" groups of paper and online examinees. The matching variables included sex, race/ethnicity, free and reduced lunch status, language proficiency, IEP, and district setting, plus the prior year's overall test score in the same content area. For grade 3, no prior test scores were available, so those samples were matched on the demographic variables only.

Scale score distributions of CMAS scores between the matched samples were compared to estimate the mode effect. To quantify the differences between the two distributions, the effect size of the differences between the two distributions was calculated as Cohen's *d* (Cohen, 1977) using the mean scale score from each group and the pooled standard deviation:

$$d = \frac{M_{group1} - M_{group2}}{SD_{pooled}}$$

Suggested interpretations of Cohen's *d* (Cohen, 1977) are as follows:

- 0.2 = a 'small' effect size
- 0.5 = a 'medium' effect size
- 0.8 = a 'large' effect size

A threshold for a possible mode effect was set to an effect size of .1 or greater and a matched sample size of at least 1,000 students. The number of students taking the paper form can be found in Tables 50 and 51. The effect size was calculated for the mathematics and ELA assessments in each grade, and the results were presented to CDE, which made the final decision on whether to make an adjustment for mode differences for each assessment.

For assessments where an adjustment was deemed necessary, scores from the paper form were adjusted using a linear transformation to match the mean and standard deviation of the online form. The conversion is applied to the overall scores. For ELA, the conversion is also applied to the Reading claim score.

Results of the spring 2019 mode adjustment analysis and the assessments for which an adjustment was applied are provided in Part II of this report.

Field Test Equating

The field test (FT) equating process for CMAS mathematics, ELA, and CSLA is similar to that of operational equating, except that the anchors are the operational items. This process placed the FT item parameter estimates onto the operational base scale. Items from all FT forms are calibrated concurrently, with the exception of the ELA constructed-response items.

For CMAS ELA, student responses to field-tested prose constructed-response (PCR) items are sampled for scoring and calibration. For each FT PCR item, a total of 3,000 responses per trait are selected for scoring. Due to possible dependency between the two trait scores for each PCR, the FT items on each ELA assessment went through two calibrations. The first calibration included all FT items except the WKL trait scores, and the second calibration included all FT items except the WE trait scores (with all OP items serving as anchors in both cases). The estimates from each calibration were then equated to the base scale separately, following the same procedures as the operational equating. Finally, the two sets of equated FT parameters were combined by adding the equated FT WKL trait estimates to the equated estimates from the first calibration. This "double-calibration" method allowed for separate calibration of the FT trait scores, while reducing the number of FT responses that needed to be scored per trait. Using a "Moulder" calibration method (as in the operational item calibration) would have meant using scoring resources to score traits that were never actually used for calibration or scoring.

Ability Estimates

CMAS Mathematics and ELA

Examinee ability was estimated using IRT pattern scoring based on examinee responses and the operational item parameter estimates. Examinee ability was estimated at the overall test level and for the Reading claim on the ELA assessment. Estimates were obtained via the maximum likelihood method (MLE) applied within the ISE software program (Chien & Shin, 2012). Pattern scores use the examinee's individual item response pattern (overall or Reading claim) to determine his or her ability estimate, which may lead to different ability estimates for the same raw score.

CSLA

After the item parameter estimates were obtained for the CSLA operational items, student abilities were estimated for each grade-level assessment by conducting an anchored calibration of the operational items' item parameter estimates. Student abilities were calculated for the overall test and the Reading claim. To obtain student ability estimates for the overall test, all the operational items were included in the anchored calibration. To obtain student ability estimates for the Reading claim, only those operational items representing the specific claim were included in the anchored calibration. The calibrations included the weighting of the PCR WE trait score. Student ability estimates were obtained via the joint maximum likelihood method (JMLE) applied within Winsteps.

Overall and Subscale Scale Scores

For CMAS mathematics, ELA, and CSLA, examinee ability estimates for the overall test were then transformed to scale scores ranging from 650 to 850 using the same scaling transformations as the prior year's administrations. For CMAS ELA and CSLA, the examinee ability estimates for the Reading claim were transformed to scaled scores ranging from 110 to 190.

The following linear transformation was used to convert examinee theta estimates into scaled scores:

$$SS = A * \theta + B$$

After the scale scores were calculated, the lowest obtainable scale score (LOSS) and highest obtainable scale score (HOSS) were applied. LOSS and HOSS were set to 650 and 850, respectively, for the overall test scale. For the Reading scale, LOSS and HOSS were set to 110 and 190.

Steps in the Calibration, Equating, and Scaling Process

The calibration, equating, and scaling process was repeated for each subject/grade. All steps were independently replicated by at least two members of the Pearson psychometric team to ensure the accuracy of the processes.

Data Preparation

Prior to any analyses, several steps were completed as preparation.

- The data file containing student responses was verified and exclusion rules were applied.
- A traditional item analysis (TRIAN) and adjudication, where applicable, were completed on all items.
- Incomplete data matrices (IDMs) were created.

Traditional Item Analysis (TRIAN) and Adjudication

A TRIAN of all items was conducted prior to calibration. The purpose of this review is to use classical statistics to identify potential test administration and score issues. Specifically, items having one or more of the following characteristics are flagged:

- P-value = 0
- Item-total score correlation < 0
- Incorrect option selected by more high-performing students (top 20%) than the keyed response
- Distractor-total score correlation > 0
- One or more score points earned by less than 5% of students

A list of flagged items is communicated to the content specialists for review and confirmation that the correct key has been applied. A sample TRIAN report is provided in Figure 8.

All TE items are put through an adjudication process. For each item, the frequency distribution of responses that are scored correctly is created along with the frequency distribution of responses that are scored as incorrect. Content specialists review each response in the frequency reports and indicate whether the response should be scored as correct. The content specialists' indications are then cross-referenced with how the responses are scored to confirm that scoring is accurate. A sample adjudication spreadsheet is provided in Figure 9.

Calibration, Equating, and Scaling

For the spring 2019 administration, several different analyses were performed to obtain item parameter estimates for online operational and field test items and ability estimates for examinees.

- CMAS mathematics (grade 8 only) and ELA
  - Online operational items
    - Used IRTPRO control files and IDM to obtain online operational item parameter estimates
    - Evaluated consistency of scoring and stability of anchor items
    - Used STUIRT to scale 2019 operational items to operational scale
    - Calculated item fit statistics and plotted expected vs. observed IRFs for each operational item
    - Used ISE to estimate student abilities
  - Online field test items
    - Used IRTPRO control files and IDM to obtain item parameter estimates of operational and field test items
    - Used STUIRT to scale field test items to operational scale using the online operational items as the anchor set
    - Calculated item fit statistics and plotted expected vs. observed IRFs for field test item
- CMAS mathematics (grades 3 through 7)
  - Online operational items
    - All items had parameter estimates already equated to the base scale
    - Used ISE to estimate student abilities
  - Online field test items
    - Used IRTPRO control files and IDM to obtain item parameter estimates of operational and field test items
    - Used STUIRT to scale field test items to operational scale using the online operational items as the anchor set

        - Calculated item fit statistics and plotted expected vs. observed IRFs for field test item

- CSLA
    - Operational items
        - Used Winsteps control files and IDM to obtain non-anchor operational item parameter estimates
        - Evaluated stability of anchor items to obtain the final anchor set
        - Used the final anchor set in Winsteps to scale the 2019 non-anchor items to the operational scale
        - Obtained item difficulty values, step deviation values, and item fit values for all items
        - Used Winsteps to estimate student abilities using the operational item parameter estimates
    - Embedded field test items
        - Used Winsteps control files and IDM to scale the embedded field test item parameter estimates to the operational scale by fixing the item parameter estimates of the operational items
        - Obtained field test item difficulty values, step deviation values, and item fit values for the field test items

CHAPTER 9: RELIABILITY

A variety of statistics can be calculated that pertain to the reliability of the CMAS mathematics, ELA, and CSLA assessments. In this report, coefficient alpha (i.e., Cronbach's alpha), standard error of measurement (SEM), conditional standard error of measurement (CSEM), decision consistent and accuracy, and inter-rater agreement are provided, as described below. For these statistical estimates from the spring 2019 administration, see Part II of this document.

Coefficient Alpha

Within the framework of Classical Test Theory, an observed test score is defined as the sum of a student's true score and error (X = T + E, where X = the observed score, T = the true score, and E = error). A true score is considered the student's true standing on the measure, while the error score reflects a random error component. Thus, error is the discrepancy between a student's observed and true score.

In the CTT framework, the reliability coefficient of a measure is the proportion of variance in observed scores accounted for by the variance in true scores. The coefficient can be interpreted as the degree to which scores remain consistent over parallel forms of an assessment (Ferguson & Takane, 1989; Crocker & Algina, 1986). There are several methods for estimating reliability; however, in this report, an internal consistency method is used. In this method, a single form is administered to the same group of subjects to determine whether examinees respond consistently across the items within a test. A basic estimate of internal consistency reliability is Cronbach's coefficient alpha statistic (Cronbach, 1951). Coefficient alpha is equivalent to the average split-half correlation based on all possible divisions of a test into two halves. Coefficient alpha can be used on any combination of dichotomous (two score values) and polytomous (two or more score values) test items and is computed using the following formula:

$$\alpha = \frac{n}{n-1}\left(1-\frac{\sum_{j=1}^{n} S_j^2}{S_X^2}\right),$$

where *n* is the number of items, S_j^2 is the variance of students' scores on item *j*, and S_X^2 is the variance of the total-test scores.

Coefficient alpha ranges in value from 0.0 to 1.0, where higher values indicate a greater proportion of observed score variance is true score variance. Two factors affect estimates of internal consistency: test length and homogeneity of items. The longer the test, the more observed score variance is likely to be true score variance. The more similar the items, the more likely examinees will respond consistently across items within the test.

Coefficient alpha estimates are provided for the overall test, each subscale, and several demographic subgroups (see Tables 3 through 17). Given the differences in length, it is expected that the coefficient alpha for the overall test will be higher than that of the subscales.

Note that coefficient alpha is reported as a measure of internal consistency of the items that each scale comprises. However, because the reported scale scores for both the overall test and the Reading claim (ELA only) are determined using IRT pattern scoring, IRT-based conditional standard error of measurement (CSEM; see the “Conditional Standard Error of Measurement” section later in this chapter) is a more appropriate measure of the measurement error associated with these scale scores.

Standard Error of Measurement

The SEM is another measure of reliability. This statistic uses the standard deviation of test scores along with a reliability coefficient (e.g., coefficient alpha) to estimate the number of score points that a student’s test score would be expected to vary if the student was tested multiple times with equivalent forms of the assessment. It is calculated as follows:

$$SEM = s_x \sqrt{1 - \rho_{XX'}},$$

where s_x is the standard deviation of test scores, and $\rho_{XX'}$ is the reliability coefficient.

There is an inverse relationship between the reliability coefficient (e.g., alpha) and SEM: the higher the reliability, the lower the SEM. SEMs for the subclaims and the Writing claim are included in Table 18.

Conditional Standard Error of Measurement

While the SEM provides an estimate of precision for an assessment, CSEM gives an indication of how measurement error varies across the score scale. Each scale score has a CSEM estimate that indicates what the most likely range of scores would be for students receiving that score if they tested multiple times. The CMAS assessments measure more accurately at a scale score of 750 (near the middle of the scale) than at 650 or 850 (at the ends of the scale). During test construction, CSEMs are reviewed to ensure that they are minimized around the performance level cut scores.

The CSEM is defined as the standard deviation of observed scores given a particular true score and is estimated within the IRT framework as the inverse of the test information function. Plots of test information curves (TICs) and CSEM across the score scale range are provided in Appendix C for both the overall scale scores and Reading claim scale scores (ELA and CSLA only).

Decision Consistency and Accuracy

The CMAS mathematics, ELA, and CSLA scales are divided into five performance levels: (1) Did not yet meet expectations, (2) Partially met expectations, (3) Approached expectations, (4) Met expectations, and (5) Exceeded expectations. Based on a student's scale score, the student is classified into one of the five performance levels. The consistency and accuracy of these performance level classifications is another important aspect of reliability to examine.

The consistency of a decision refers to the extent to which the same classification would result if a student were to take two parallel forms of the same assessment. However, since test-retest data are not available, psychometric models can be used to estimate the decision consistency based on test scores from a single administration. The accuracy of a decision refers to the agreement between a student's observed score classification and a student's true score classification, if a student's true score could be known.

Procedures developed by Livingston and Lewis (1995) were used to estimate the consistency and accuracy of performance level classifications for CMAS mathematics, ELA, and CSLA. For the overall test, consistency and accuracy estimates along with PChance and Cohen's Kappa (κ) coefficient (Cohen, 1960) are provided in Table 19 according to the following equation:

$$\kappa = \frac{P - P_c}{1 - P_c},$$

where P is the probability of consistent classification, and P_c is the probability of consistent classification by chance (Lee, Hanson, & Brennan, 2000).

In addition, consistency and accuracy estimates at each cut score are provided in Tables 20 and 21.

Inter-Rater Agreement

For CR items, an additional form of reliability is assessed. Inter-rater agreement examines the extent to which examinees would obtain the same score if scored by different scorers. The following analyses will be conducted for each CR item, where R_1 is the first rater and R_2 is the second rater of the analyses.

- Agreement rates
    a. Exact, which represents exact agreement between the two raters
    b. Adjacent, which represents adjacent agreement between the two raters (i.e., a difference of 1 score points)
    c. Non-adjacent, which represents a difference of more than 1 score point between the two raters

For the CMAS ELA and CSLA CR items (i.e., PCR task items), the following additional analyses are also conducted:

- Quadratic kappa (Kappa)

  $KAPPA = \frac{E([X_1 - Y_1]^2)}{E([X_1 - Y_2]^2)}$, which is a comparison between the mean square error of rating pairs that are supposed to agree (X_1, Y_1) and those that are unrelated (X_1, Y_2)

- Standardized mean differences (MD)

$$\bar{Z} = \frac{\left|\bar{X}_{R_1} - \bar{X}_{R_2}\right|}{\sqrt{\frac{sd_{R_1}^2 + sd_{R_2}^2}{2}}}$$

- Correlations (CORR)

$$\bar{Z} = \frac{\left|\bar{X}_{R_1} - \bar{X}_{R_2}\right|}{\sqrt{\frac{sd_{R_1}^2 + sd_{R_2}^2}{2}}}$$

Rater agreement statistics for both operational and field test items are provided in Tables 22 through 49.

CHAPTER 10: VALIDITY

“Validity refers to the degree to which evidence and theory support the interpretations of test scores for proposed uses of tests” (AERA, APA, NCME, 2014). As such, it is not the CMAS mathematics and ELA (including CSLA) assessments that are validated but rather the interpretations of the scores. The purpose of the CMAS mathematics and ELA (including CSLA) assessments is to provide information about a student’s level of mastery of the CAS. These standards were designed such that mastery of the high school level standards should mean that a student is ready for success in college and/or career. Mastery of the standards in the elementary and middle school grades indicates that a student is on track to being college and career ready at each grade level. In support of these ends, the previous chapters of this report described processes that were implemented throughout the CMAS and CSLA assessment cycle with validity and fairness considerations in mind. This chapter provides information regarding specific sources of validity evidence as well as fairness.

Sources of Validity Evidence

The following sections describe various sources of validity evidence as outlined in the *Standards for Educational and Psychological Testing* (AERA, APA, NCME, 2014).

Evidence Based on Test Content

Evidence based on the content of the assessment is supported by the degree of correspondence between test items and content standards. The degree to which the test measures what it claims to measure is known as construct validity. The CMAS mathematics, ELA, and CSLA assessments adhere to the principles of evidence-centered design, in which the standards to be measured (the CCSS and CAS) are identified, and the performance a student needs to achieve to meet those standards is delineated in the ESs. Test items are reviewed for adherence to universal design principles, which maximize the participation of the widest possible range of students.

The item development process for the assessments is driven by targets at the ES level. Before developing items, Pearson uses target spreadsheets to create an internal item development plan (IDP) aligned with the expectations of test design and with consideration of attrition rates at committee review and data review.

In addition to the ESs, content is aligned through the articulation of performance in the PLDs. At the policy level, the PLDs include policy claims about the educational achievement of students who attain a particular performance level, and a broad description of the grade-level knowledge, skills, and practices that students performing at a particular achievement level are able to demonstrate. Those policy-level descriptors are the foundation for the subject- and grade-specific PLDs, which, along with the ES framework, guide the development of the items and tasks.

Gathering construct validity evidence for CMAS mathematics and ELA (including CSLA) is embedded in the process by which CMAS assessment content is developed and validated. At each step in the assessment development process, educators, assessment experts, and bias and sensitivity experts were involved in review of text, items, and tasks for accuracy, appropriateness, and freedom from bias. See Chapter 2 for an overview of the content development process. In the early stages of development, Pearson conducted research studies to validate the item and task development approach. One such study focused on student task interaction and was designed to collect data on students' experience with the assessment tasks and technological functionalities, as well as the amount of time needed to answer each task. Pearson also conducted a rubric choice study that compared the functioning of two rubrics developed to score the prose constructed-response (PCR) tasks in ELA. Quantitative and qualitative evidence was collected to support the use of a condensed or expanded trait scoring rubric.

A portion of the operational items on each assessment were developed by a multi-state consortium and field tested prior to 2018. The Technical Report for the 2018 CMAS administration includes details on item development for those items carried forward from the PARCC consortium.

An important consideration when constructing test forms is recognition of items that may introduce construct-irrelevant variance. Such items should not be included on test forms to help ensure fairness to all subgroups of test takers. Data reviews and content and bias reviews are held with Colorado educators to identify any issues with items before they are included on an operational test form. Details on these committees can be found in Chapter 2. Accommodations were made available based on individual need documented in the student's approved IEP or 504 Plan. Available accessibility features and accommodations are described in Chapter 4.

The mathematics and ELA operational test forms were carefully constructed to align with the test blueprints and specifications that are based on the CAS. Chapter 3 provides details on the construction of the operational assessment forms for 2019.

Evidence Based on Internal Structure

Analyses of the internal structure of a test typically involve studies of the relationships among test items and/or test components (i.e., subclaims) in the interest of establishing the degree to which the items or components appear to reflect the construct on which a test score interpretation is based (AERA, APA, & NCME, 2014, p. 16). The term 'construct' is used here to refer to the characteristics that a test is intended to measure; in the case of the CMAS mathematics, ELA, and CSLA operational tests, the characteristics of interest are the knowledge and skills defined by the test blueprints.

The CMAS mathematics, ELA, and CSLA assessments provide a full summative test score and a Reading claim score, as well as percent of points earned scores for the Writing claim and ELA and mathematics subclaims. The goal of reporting at this level is to provide criterion-referenced data to assess the strengths and weaknesses of a student's achievement in specific components of each content area compared with other students taking the same assessment (for claim and subclaim scores) as well as students who took the assessment in prior years (for overall scores). This information can then be used for a variety of purposes:

At school and district levels, CMAS results:

- may be used as a prompt for further investigation at the student, classroom, school, and district levels;
- support districts and schools in reviewing and developing goals for the performance of their students, including subgroups;
- may indicate that a review of programs, curricula, materials and/or scope and sequence may be appropriate; and
- may inform the evaluation of district/school approaches.

Educators can use the provided assessment scores to plan for further instruction, to plan for curriculum development, and to report progress to parents. The results can also be used as one factor in making administrative decisions about program effectiveness, teacher effectiveness, class grouping, and needs assessment. CMAS results can also be used for research purposes and for informing community and organization efforts.

Intercorrelations

The ELA and CSLA summative tests comprise two claim scores, Reading and Writing, and five subclaim scores—Reading Literature (RL), Reading Information (RI), Reading Vocabulary (RV), Writing Written Expression (WE), and Writing Knowledge Language and Conventions (WKL). The Reading claim score is a composite of RL, RI, and RV. The Writing claim score is reported only as a percentage of points earned. It is a composite of WE and WKL, and comprises only PCR items. The operational test analyses were performed by evaluating the separate trait scores of WE and WKL. Some PCR items also include RL or RI points; however, the reading points for those items were a duplicate of the WE score and were not included in calibrations.

The mathematics full summative tests have four subclaim scores—Major Content (MC), Mathematical Reasoning (MR), Modeling Practice (MP), and Additional and Supporting Content (ASC).

One way to assess the internal structure of a test is through the evaluation of correlations among subscores. For CMAS ELA and CSLA, these analyses were conducted between the Reading and Writing claim scores and the subclaims (RL, RI, RV, WE, and WKL). For CMAS mathematics, the analyses were conducted between the mathematics subclaim scores. There is evidence of unidimensionality if the components within a content area are strongly related to each other.

Reliability

The reliability analyses described in Chapter 8 of this report provide information about the internal consistency of the CMAS mathematics, ELA, and CSLA assessments. Internal consistency is typically measured via correlations amongst the items on an assessment and provides an indication of how much the items measure the same general construct. High reliability of test scores implies that the test items within a domain are measuring a single construct, which is a necessary condition for validity when the intention is to measure a single construct. Table 3 provides reliability estimates for the overall population for the full tests, the ELA and CSLA claims and subclaims, and the mathematics subclaims. Tables 4–17 also provide reliability estimates for subgroups of interest. The reliability estimates were computed using coefficient alpha, and were also used in the calculation of CTT-based estimates of SEM (described in Chapter 8).

Factor Analysis

A factor analysis was performed on the item response data for the CMAS assessments to analyze the number of dimensions the assessments appear to be measuring. Given that unidimensional IRT models are used for calibration and scaling, it is important that there be evidence to support their use. Scree plots for the spring 2019 administrations can be found in Figures 24 through 37. For most of the assessments, one factor explained the vast majority of the variance, which supports the use of a unidimensional IRT model. The scree plots indicate a strong underlying single factor for each assessment, although many of the tests suggest the presence of a less influential second factor. The second factor is more apparent for the ELA assessments, and the loadings for factor 2 for ELA were all much higher for the PCR trait items than any other items. This may indicate the influence of a writing construct that is separate from what is measured by the reading items.

Evidence Based on Relationships to Other Variables

Correlations were calculated between the ELA and mathematics assessments. These scores may be expected to have lower correlations if the tests are measuring distinct constructs. The correlations between ELA and mathematics scale scores were fairly high for students who had valid scores on both assessments. However, the values are very close to the 2018 values (see the *CMAS Mathematics & ELA (including CSLA) Technical Report 2018*). Table 131 provides the correlations between ELA and mathematics.

Evidence Based on Response Processes

As noted in the AERA, APA, and NCME *Standards* (2014), additional support for a particular score interpretation or use can be provided by theoretical and empirical evidence indicating that test takers are using the intended response processes when responding to the items in a test. This type of evidence may be gathered from interacting with test takers in order to understand what processes underlie their item responses. Evidence may also be derived from feedback provided by test proctors/teachers involved in the administration of the test and raters involved in the scoring of constructed-response items. Evidence may also be gathered by evaluating the correct and incorrect responses to short constructed-response items (e.g., items requiring a few words to respond) or by evaluating the response patterns to multi-part items.

Prior to the 2016 administration the PARCC consortium undertook research investigating the quality of the items, tasks, and stimuli, focusing on whether students interact with the online items/tasks as intended through Cognitive Labs. In these studies, students were asked to narrate how they interact with an item and answer questions about their experience with the item and online platform.

As new items are developed, the responses submitted during the field test are reviewed. Sample responses to the constructed response items are reviewed by educator committees during rangefinding to ensure that the rubrics make sense with the responses that were received in addition to providing example scored responses. During the Data Review meeting, item statistics are reviewed to ensure that the students are responding to items in the expected way. Low item point-biserial correlations and aberrant response distributions can all indicate that there are unexpected issues with either the correct or incorrect responses. Items where the correct response is not accurate or there are distractor responses that are technically correct can be identified and rejected at this step.

During the adjudication step, incorrect responses to fill-in-the-blank items are reviewed to make sure that no technically correct responses are excluded. These include entry issues such as extra spaces or unexpected responses such as adding an unnecessary decimal (e.g. ‘3.0’ rather than ‘3’).

Evidence Based on the Consequences of Testing

Because state tests are administered “with the expectation that some benefit will be realized from the intended use of the scores” (AERA, APA, & NCME, 2014), validity evidence supporting the use and interpretation of CMAS mathematics and ELA (including CSLA) assessment results may be investigated as a consequence of testing.

One intended consequence of testing is that more students will demonstrate mastery over the Colorado Academic Standards over time, as evidenced by more students achieving in the top performance levels, if the data are used appropriately to make improvements in programming at the school and district levels. The CMAS mathematics and ELA assessments have been administered to Colorado students since the spring of 2015. The table below shows that with the exception of grade 6 math, student performance has improved since the first administration of the assessments. *Note: There have been changes in the available assessments by grade for 7th and 8th grade math across assessment administration, so comparisons across years for those grades are not included.*

Subject	Grade	2015 % Met or Exceeded	2019 % Met or Exceeded	% Change 2015 to 2019
ELA	3	38.2	41.3	3.1
	4	41.7	48.0	6.3
	5	40.5	48.4	7.9
	6	39.1	43.6	4.5
	7	41.0	46.5	5.5
	8	40.9	46.9	5.9
Math	3	36.7	41.0	4.3
	4	30.2	33.6	3.4
	5	30.1	35.7	5.6
	6	31.7	29.5	-2.2

Fairness

Fairness is an important aspect of validity, as it is critical that an assessment provide accurate measurements for **all** students. To that end, fairness considerations were woven into the development and administration of the CMAS assessments.

Sample Items

Sample items provide the opportunity for teachers and students to become familiar with the test design and scoring of the assessments before experiencing the items on an operational test. Prior to the operational administration, teachers and students are provided the opportunity to experience sample items for CMAS mathematics and ELA (including CSLA).

CMAS mathematics and ELA online sample items are included in practice environments called ePATs. As the assessment system progresses, ePATs are updated to reflect current accessibility features and any updates to Pearson TestNav that may impact student interactions with the system. Accommodated versions of the ePATs are also available so that students can practice using accommodations and accessibility features such as text-to-speech, color contrast, and Spanish text-to-speech. Paper sample items for students taking paper versions of the assessments (including CSLA) are available in PDF format for download and are accompanied by scoring and alignment documents.

Universal Design

The CMAS mathematics and ELA (including CSLA) development process adheres to the principles of universal design with the goal of avoiding construct-irrelevant aspects of the assessment as described in Chapter 2 of this document.

DIF

As outlined in Chapter 2, all CMAS mathematics and ELA (including CSLA) items were field tested and then analyzed for DIF in order to identify any items that appeared to be unfairly favoring one subgroup over another. All DIF-flagged items were then reviewed by educator committees to identify potential construct-irrelevant explanations for the flags.

Accessibility Tools and Accommodations

As described in Chapters 3 and 4, various accessibility tools and accommodations are available for students who take CMAS mathematics, ELA, and CSLA. The online testing format allows for accessibility features like text-to-speech and color contrast to be available to all students. In addition, accommodations are available for students who need them and include paper, large print, braille forms, and oral scripts; as well as online forms designed to work with assistive technology such as screen readers. Students may also have extended time as required by their IEP or as allowed for students classified as English learners. The test is also available with Spanish text-to-speech (mathematics only) and paper transadaptions or oral scripts that can be translated into other languages. Some accommodations (i.e. oral presentation and scribe for constructed response items) require approval on the ELA assessment in order to preserve the intended construct of reading and writing according to the Colorado Academic Standards (see Chapter 4). The CSLA assessments were developed to be linguistically accommodated Spanish tests in accordance with Colorado state law. The purpose of these various options is to allow students to fully demonstrate their content knowledge without being hindered by non-construct related elements.

PART II: STATISTICAL SUMMARIES FOR 2019

This section contains an overview of the statistical summaries for the following administrations:

- Spring 2019 Operational Exam
- Spring 2019 Embedded Field Test

For the operational administration, administration summaries, calibration results, performance results, reliability evidence, and validity evidence will be included. For the embedded field test, form summaries, rater agreement statistics, and data review outcomes are provided.

CHAPTER 1: SPRING 2019 OPERATIONAL ASSESSMENT

The following section provides details on the spring 2019 administrations of the CMAS mathematics and ELA (including CSLA) assessments.

Administration Summary

Tables 50 and 51 provide a breakdown of online test takers compared with those who took accommodated forms for mathematics and ELA. Although a paper form was available to all students, the vast majority took the assessments online.

Tables 52 through 54 provide n-counts for various demographic characteristics for the students who took the CMAS mathematics and ELA (including CSLA) assessments.

Equating Results

Calibration and Anchor Set Evaluation

CMAS Mathematics (grade 8 only) and ELA

The initial calibration results were reviewed for problematic item parameter estimates, and fit plots were examined to detect items with poor model–data fit. Based on the initial calibration, one item on the grade 4 ELA assessment was removed from the final calibration and suppressed from scoring.

Review of anchor item stability analyses resulted in dropping zero to one items from the anchor set, depending on grade and subject. The final anchor sets for grade 8 mathematics represented 31% of the total test points, and the final anchor sets for ELA represented between 33% and 47% of the unweighted total test points.

As described in Chapter 8, the online and paper versions were constructed to be parallel, and item parameter estimates were assumed to be the same. The information provided for the item statistics and IRT curves are based on the online estimates.

Post-Equating Check (CMAS Mathematics grades 3–7 only)

The mathematics assessments in grades 3 through 7 were pre-equated, meaning that all items had already been administered, with item parameters already estimated and placed onto the base scale. Students were scored based on these previously banked item parameter estimates. Because pre-equating relies on stronger assumptions than post-equating, an additional post-equating analysis was conducted and compared with the pre-equated results. If large discrepancies existed between the two, it could suggest that pre-equating assumptions have not been met. Conversely, similarity between pre- and post-equated item parameters suggests that the pre-equated item parameters are appropriate for students taking the current form.

The post-equating check followed the same procedures as those of the other post-equated assessments, using an anchor set for each assessment that was identified during test construction and that met the operational anchor test specifications.

Results of the post-equating check suggested that pre- and post-equated item parameters were quite similar. Figures 38 through 42 compare the pre-equated and post-equated TCCs for each assessment. The results of the check show that post-equated scores would have been highly similar to the pre-equated results. The largest absolute difference between TCCs across all grades was 1.2%, which was observed in grade 4 just below the level 5 cut. The high degree of similarity across the entire scale score range for each grade suggests that pre-equating assumptions were met and that the pre-equated item parameters were appropriate for this administration.

CSLA

For CSLA, the calibration results after the operational administration were reviewed and evaluated as part of the stability check. The final anchor sets for grades 3 and 4 represented 36% and 31%, respectively, of the unweighted total test points. One item on the grade 3 assessment was removed and suppressed from scoring before conducting the initial calibration.

Item Statistics

Tables 55 through 68 provide the item parameter estimates for each grade. (Note that the Item numbers are merely identifiers, and do not reflect the sequence of items as they were presented to students.) The "Item Type" uses the coding of SR for selected-response, XI for technology-enhanced, and CR for constructed-response items. The "Model" refers to the IRT model under which the item was estimated (2PL, GPC, or RPCM). The "A" column shows the item parameter estimate for discrimination, "B" for difficulty, and "D1" through "D7" for GPC or RPCM category threshold estimates. Not all item parameters apply to each item. For example, there are no category threshold estimates for 2PL items.

The last column of the mathematics (grade 8 only) and ELA tables reflects whether an item was flagged for misfit based on Q1. Several items in each grade were flagged for misfit. Misfit plots for all items were reviewed, and misfit statistics were compared with data from the previous administration. Based on these reviews, no additional items were removed due to misfit flags. For CSLA, the "Infit" and "Outfit" columns contain the item fit values.

See Chapter 8 for detailed information about the calibration process.

IRT Curves

The test characteristic curves (TCCs), test information curves (TICs) and CSEM curves for both the overall scale scores and the Reading claim scale scores (ELA and CSLA only) are provided in Appendix C. The 2019 TCCs matched those from 2018 in terms of shape and position. The 2019 TCCs were reviewed across the distribution as well as at the cuts to ensure the match between years. Additionally, Colorado’s established maximum TCC difference of 0.05 was maintained between the 2018 and 2019 forms. It should be noted that the TCCs are provided in terms of expected percent correct rather than expected raw score. Along with the curves, each of the four cut scores for a given grade is indicated with a red vertical line, as are the cut scores for the Reading claim. On the overall scale score TCCs, the vertical line at a scale score of 750 corresponds to the cut for Met Expectations for each assessment.

Performance Results

The cumulative scale score distributions for each grade are shown in Tables 69 through 94. Figures 10 through 23 display the same information in graphical form.

Table 95 provides summary statistics for overall scale scores. Means, standard deviations, and medians are provided. The 2018 scale score means and standard deviations are also included for comparison.

The performance level distributions for each grade are shown in Table 96. With the exception of grade 8 mathematics, the distributions within each performance level are similar across grades. for both CMAS mathematics and ELA. Table 96 also lists the same distribution for the 2018 administration for comparison.

Summary statistics for points earned by subclaim are shown in Tables 97 through 99. Note that the assessments are constructed and scaled to produce overall scores and Reading claim scores that are comparable with overall scores and Reading claim scores from previous CMAS administrations (see Chapter 8 in Part 1 of this report). However, the assessments are not designed to permit meaningful comparisons across percent earned scores, such as subclaim scores, either within an assessment or across administration years, nor are they designed to permit comparisons of the Writing claim scores across administration years. The difficulty of the items that make up each subscore can vary across subscores and from year to year, making it inappropriate to make inferences based on percent-correct performance across subscores or based on subscore performance across years. The only percent earned subscore comparisons supported by the CMAS assessments are those comparing individual or group performance within one sub-category with the performance of other students or groups within the same sub-category and administration.

Tables 100 through 126 provide classical statistics at the item level for the CMAS mathematics, ELA, and CSLA assessments. For SR items, the omit rate, p-value (the item mean and, for 1-point items, the percentage of students correctly responding to an item), and item-total correlation are given. For CR items, the percentage of students earning each score point is provided in addition to the statistics included with the SR items.

Correlations were calculated between the subclaims for each assessment. For CMAS ELA and CSLA, correlations between the Reading and Writing claim were also calculated. These results are provided in Tables 127 through 130.

Reliability Statistics

Coefficient Alpha

Coefficient alpha was calculated for both the content subclaims and the overall assessment, as shown in Table 3. The internal consistency values for the full assessment ranged from 0.84 to 0.92.

Tables 4 through 17 display performance by various subgroups. The scale score means, standard deviations, minimums, and maximums, as well as overall coefficient alpha values, are provided.

SEM

Table 18 shows the SEMs that were calculated for each grade for each subclaim and for the Writing claim score (ELA and CSLA only), based on the reliabilities reported in Table 3. The classical SEM estimate is not reported for the overall test scale scores and the Reading claim scores, as those scores are based on IRT pattern scoring rather than the sum of item scores.

CSEM

IRT-based test information curves (TICs) and conditional standard error of measurement (CSEM) curves for the overall scale scores and the Reading claim scores are included in Appendix C.

Decision Consistency and Accuracy

Tables 19 through 21 provide statistics related to decision consistency and accuracy. Table 19 shows accuracy and consistency estimates in addition to probabilities due to chance (PChance) and kappa for the entire assessment. Kappa describes the agreement between classifications on two parallel forms. The kappa value can be interpreted as follows (Altman, 1991):

Value of Kappa	Strength of Agreement
< 0.20	Poor
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Very Good

Tables 20 and 21 provide the accuracy and consistency estimates at each of the cut scores.

Inter-Rater Agreement

For each operational item, five percent of the responses were scored by a second reader, which allowed for rater agreement statistics to be calculated. Tables 22 through 35 provide the percentage of operational items with exact agreement, adjacent agreement, and non-adjacent agreement. Tables 36 through 49 provide rater agreement information for field test items. The target exact plus adjacent agreement rate is 95% for all items.

Validity Statistics

Intercorrelations

As described in Chapter 10, Tables 127 through 130 list correlations between the subclaims within each assessment, as well as between the Reading and Writing claims for the CMAS ELA and CSLA assessments. The intercorrelations for the mathematics subclaims were higher overall than the ELA and CSLA intercorrelations, although most values for all assessments were between 0.4 and 0.7. For CMAS ELA and CSLA, the two writing subclaims tended to have higher correlations with one another than they did with any of the reading subclaims.

Reliability

Reliability statistics for the overall test, the subclaim scores, and several demographic subgroups are presented in Tables 3–17. The full test reliabilities range from 0.84 to 0.92. The overall test reliability does not correspond directly with the overall student scale scores, as those are based on IRT pattern scoring. However, the overall estimates do provide evidence of unidimensionality of the assessments. Furthermore, the subgroup reliabilities were fairly consistent for the various demographic subgroups, with the exception of those based on language proficiency. The reliability of the tests tended to be lower for students identified as non-English proficient or limited English proficient.

Factor Analysis

A factor analysis was conducted for each grade, and scree plots were constructed to display the relative size of each eigenvalue, as shown in Figures 24 through 37. The results support the use of a unidimensional IRT model, although the ELA and CSLA scree plots do suggest that the Reading and Writing claims are distinct subscores.

CHAPTER 2: SPRING 2019 EMBEDDED FIELD TEST

This section provides details on the field test items that were embedded within the spring 2019 administration of the CMAS mathematics, ELA, and CSLA assessments. Due to low n-counts on other forms, only items embedded in the online English forms were analyzed for CMAS mathematics and ELA.

Field Test Forms

For CMAS mathematics, between nine and 12 field test forms were administered, depending on grade level. For CMAS ELA, either eight or 16 field test forms were administered depending on grade level. For CSLA, four field test forms were administered for grade 3 and two field test forms were administered for grade 4. For CMAS mathematics, ELA, and CSLA, each field test form within a grade was parallel; that is, each student received field test items worth the same number of points per item type, and the item locations were the same or matched as closely as possible across forms. Table 132 shows the number of field test forms and field test items per assessment and grade.

Inter-Rater Agreement

For each CR item, responses were scored by highly qualified scorers, as described in Chapter 5. A 5% subset of those responses were scored by two readers, which allowed for inter-rater reliability calculations. Rater agreement statistics can be found in Tables 36–49, where the percentage of items with exact agreement, adjacent agreement, and non-adjacent agreement are provided. In addition, the final columns for ELA and CSLA items show the kappa, mean difference, and correlation for each item. Items with poor rater agreement during field testing are reviewed by Pearson and CDE content experts for issues with the item or scoring rubric. These items may be field tested again after adjustments to the item or scoring rubric or removed from the bank.

Data Review

The data review meetings for the spring 2019 embedded field test items were conducted by web-based teleconference in late July and early August. For CMAS mathematics and ELA, the meetings were conducted by grade level and content area, with each committee reviewing items from one content area and two grade levels (e.g., ELA grades 3 and 4, ELA grades 5 and 6, and ELA grades 7 and 8). For CSLA, one committee was convened to review both grades 3 and 4. The committees for CMAS mathematics and ELA comprised educators with expertise in both the content area being assessed and Colorado students in the particular grade levels being reviewed. The CSLA committee comprised experts in bilingual instruction and English learners at the elementary grades. Prior to the meetings, field test data were analyzed and items were flagged based on classical statistics and DIF. Items that were flagged were taken through the data review process.

The data review meetings were facilitated by Pearson and Tri-Lin assessment specialists. Also attending each meeting were a Pearson psychometrician and representatives from CDE, including a CDE content specialist. Committee members received training on the purpose of the data review meeting and how to interpret the statistical information that would be provided. The committee members were notified that their decision on each item would serve as a recommendation to CDE, which was responsible for making the final accept/reject decision.

Table 133 summarizes the outcomes of the data review. It should be noted that although committee members were given only the choice between recommending to accept or reject an item, in several cases the committee suggested revisions to the item. These suggestions were recorded for potential re-field testing of the item.

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