# ACT® Aspire® Summative Technical Manual

**August 2020**

Version 2020.1

ACT® Aspire®

www.act.org

## Commitment to Fair Testing

ACT endorses and is committed to complying with The Standards for Educational and Psychological Testing (AERA, APA, & NCME, 2014). ACT also endorses the Code of Fair Testing Practices in Education (Joint Committee on Testing Practices, 2004), which is a statement of the obligations to test takers of those who develop, administer, or use educational tests and test data in the following four areas: developing and selecting appropriate tests, administering and scoring tests, reporting and interpreting test results, and informing test takers. ACT endorses and is committed to complying with the Code of Professional Responsibilities in Educational Measurement (NCME Ad Hoc Committee on the Development of a Code of Ethics, 1995), which is a statement of professional responsibilities for those involved with various aspects of assessments, including development, marketing, interpretation, and use.

We encourage individuals who want more detailed information on a topic discussed in this manual, or on a related topic, to contact ACT.

| Version | Date | Type | Description |
|---|---|---|---|
| 2020.1 | August 2020 | Annual update | General text and data updates. |
| 2019.1 | Fall 2019 | Annual update | General updates. |



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# Preface

The *ACT Aspire Technical Manual* contains detailed technical information about the ACT Aspire® summative assessment. The principal purpose of the manual is to document technical characteristics of the ACT Aspire assessment in light of its intended purposes. The *ACT Aspire Technical Manual* documents the collection of validity evidence that supports appropriate interpretations of test scores and describes various content and psychometric aspects of the ACT Aspire. Multiple test design and development processes are articulated documenting how ACT attends to building the assessment in line with the validity argument and how concepts like construct validity, fairness, and accessibility are attended to throughout the process. Also described are routine analyses designed to support ongoing and continuous improvement and research intended to assure the program remains psychometrically sound.

ACT endorses and is committed to industry standards and criteria. ACT endorses and is committed to complying with *The Standards for Educational and Psychological Testing* (AERA, APA, & NCME, 2014). ACT also endorses the *Code of Fair Testing Practices in Education* (Joint Committee on Testing Practices, 2004), which is a statement of the obligations to test takers of those who develop, administer, or use educational tests and test data in the following four areas: developing and selecting appropriate tests, administering and scoring tests, reporting and interpreting test results, and informing test takers. ACT endorses and is committed to complying with the *Code of Professional Responsibilities in Educational Measurement* (NCME Ad Hoc Committee on the Development of a Code of Ethics, 1995), which is a statement of professional responsibilities for those involved with various aspects of assessments, including development, marketing, interpretation, and use.

We encourage individuals who want more detailed information on a topic discussed in this manual, or on a related topic, to contact ACT.

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Chapter 1

# General Description of ACT Aspire Assessments and Standards

## 1.1 Overview

The ACT Aspire® Summative Assessment program includes a vertically scaled battery of achievement tests designed to measure student growth in a longitudinal assessment system for grades 3–early high school (EHS) in English, reading, writing, mathematics, and science. Taken as individual subject tests or as a battery, ACT Aspire can be delivered via paper or online administration. The scale scores are linked to college and career data through scores on the ACT® test and the ACT National Career Readiness Certificate® (ACT NCRC®) program. To enhance score interpretation, reporting categories for ACT Aspire use the same terminology as the ACT College and Career Readiness Standards (ACT CCRS) and other standards that target college and career readiness, including the standards of many states and the Common Core State Standards (CCSS).

## 1.2 Purposes, Claims, Interpretations, and Uses of ACT Aspire

The purpose of the ACT Aspire Assessments is to measure student achievement and progress toward college and career readiness. To identify college and career readiness constructs, ACT uses empirical and performance data to define requisite constructs in the content areas of English, reading, writing, mathematics, and science. ACT administers the ACT National Curriculum Survey study to identify what kindergarten through postsecondary teachers, including instructors of entry-level college and workforce-training courses, expect of their entering students—this includes the most current knowledge and skills students need to be ready for entry-level postsecondary courses and job training. ACT also collects data about what is actually being taught in elementary, middle, and high school classrooms. All together, these results support ACT Aspire's curriculum base and ACT's ability to identify the key skill targets and knowledge that is most important for students to know to be ready for the next step. ACT uses these and other research results to design assessments and inform test blueprints so that each test targets the most important college and career readiness skills across skill progressions.

Additional validation of the constructs occurs through ACT's longitudinal research (see Figure 1.1).

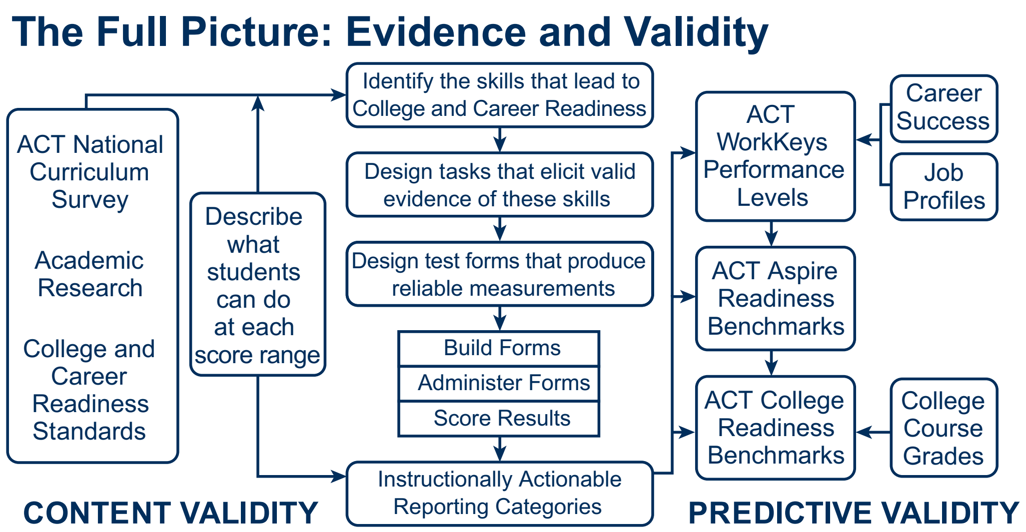


**Figure 1.1. The full picture: evidence and validity.**

Figure 1.1 shows how ACT uses research including empirical feedback loops to help inform continual improvement. ACT Aspire development starts by exhaustively understanding the most important requirements and most desired evidence needed to support inferences about college and career readiness, and tests are designed specifically to elicit the identified evidence. Subject-matter experts (SMEs), item writers, and other educators work collaboratively to write items and review them for accuracy, appropriateness, and fairness. Operational forms are put together using pretested items and are built to test specifications. Scores from assessments are calculated, reported, and sent out on various reports designed for each audience. Reporting categories provide detailed information about how students perform on key skills that instructors can act on immediately. Additional psychometric work continues, including analyzing student performance along the kindergarten to early high school continuum. Students who meet readiness score benchmarks at one grade are compared to students who succeed in the next grade. This information is used to ensure the benchmarks are accurate and up to date. Through research and feedback loops, ACT ensures that key targets are identified and measured appropriately across the continuum.

ACT Aspire was created by employing a theory-of-action approach that fuses content validity (academic research) with predictive validity (empirical data), thus following similar methodologies used to build the ACT. The theory of action begins by answering fundamental questions about the purpose of the assessment, such as, Who are the intended users? What are the intended uses of the assessment results? What are the consequences that may result from using the assessment? What are the intended interpretations or claims based on the assessment? What are measurable outcomes from using the assessment? The answers to these questions emerge from rigorous research and data collection that inform and allow high-value skill targets in each subject to be identified, resulting in focal points for developing tasks and test forms. The procedure set forth by the theory of action further gives rise to hypothesized mechanisms or processes for bringing about the intended goals of the assessment results. For example, cognitive labs, piloting, and field testing are used to validate results and continually improve the specifications and design of the assessment. Results are used to continually improve the components of the assessment.

Individual aspects of the test design ensure that items and test forms provide the evidence necessary to support the claims made by the assessment. For example, content and item specifications, test blueprints, and benchmarks influence the technical quality and output of test items and forms. These components are informed by several factors, including the following:

- Academic research on skill targets, sequencing of skills, and grade placement
- Data and evidence of student understanding collected from the assessments
- The ACT National Curriculum Survey
- Survey of standards frameworks including, but not limited to, the ACT CCRS, CCSS, and Next Generation Science Standards
- Subject-matter experts (SMEs)

The principal uses of ACT Aspire Summative are the following:

1. To measure progress toward meeting college and career readiness content standards
2. To measure progress toward meeting empirically-derived college and career readiness performance standards

Secondary uses of ACT Aspire Summative are the following:

3. To provide instructionally actionable information to educators.
4. To inform evaluation of school and program effectiveness
5. To help gauge students' readiness for advanced high school coursework
6. To understand student and group performance relative to national norms

# 1.3 ACT Aspire: Performance-Level Descriptors and College and Career Readiness Standards

ACT Aspire assessments are aligned with leading frameworks of content standards that target college and career readiness. ACT Aspire performance-level descriptors (PLDs) have been created to provide specific descriptions of student performance within and across grades. The PLDs were developed in a 2016 study run by an independent facilitator; over 90 subject-matter experts (SMEs) from 14 states drafted the PLD statements. The PLDs at each grade are organized in four performance levels: In Need of Support, Close, Ready, and Exceeding. The cut score for the Ready level is based on the ACT Readiness Benchmark at that grade. The ACT Readiness Benchmarks were derived empirically by working backward from the ACT College and Career Readiness Benchmark scores, which indicate the level of achievement required for success at the next level (see Chapter 13 for details). In the 2016 PLD study, SMEs reviewed ACT Aspire materials, performance data, and administered test items to generate statements that describe what students know and are able to do within each category in each subject and grade. PLDs are found at https://www.act.org/content/act/en/products-and-services/act-aspire/about-act-aspire/performance-level-descriptors.html.

In addition, ACT Aspire assessments in grade 8 and EHS are aligned with the ACT College and Career Readiness Standards (CCRS). The ACT CCRS, developed for each content test, are descriptions of the skills and knowledge that ACT has empirically linked to readiness in postsecondary education and the world of work. Different groups of SMEs developed the ACT CCRS by synthesizing the domain-specific knowledge and skills demonstrated by students in particular score bands across thousands of students' scores. Within each content area, the CCRS are organized by strand, which mirrors the reporting categories featured in ACT Aspire, and by score band. The ACT CCRS are organized into six achievement levels, and each level is defined by a 3-point score band. The CCRS also indicate the ACT College Readiness Benchmarks in each content area (except on the optional Writing test) that were derived using test performance and college placement data. The ACT College Readiness Benchmark scores are clearly delineated on the CCRS tables (see the ACT Technical Manual for more information on deriving the ACT CCRS and ACT College Readiness Benchmarks).

Science learning standards often vary dramatically across states and organizations, both in content and sequence. ACT Aspire science assessments for grades 3 through high school are associated with the ACT and ACT Aspire Science Knowledge and Skills Domain (see Table 3.22. which also shows how this domain relates to the ACT College and Career Readiness Standards). To develop the statements in this domain, SMEs and measurement specialists examined multiple state science standards document as well as several sources including ACT's assessment evidence, research in science education, the Next Generation Science (NGSS) Standards, National Assessment of Educational Progress (NAEP) findings, and input from nationally known SMEs in elementary science education. These statements were then used to develop the ACT Aspire PLDs. The ACT Aspire PLDs describe student achievement in more detail across grades and at different scale-score levels.

## 1.4 ACT Aspire and Standards Alignment

Many college and career readiness standards exist including the ACT CCRS, the CCSS, the NGSS and unique standards from states across the United States. The purpose of these standards is to articulate requisite knowledge and skills for postsecondary and career success. As previously described, ACT Aspire assessments are designed to measure progress and provide evidence to back up the claim that students are on target for college and career readiness.

To demonstrate alignment, evidence must be provided that assessment scores support inferences about student achievement and content knowledge identified by a given set of expectations (often articulated by a state's standards). Some assessments are designed to measure a single set of content standards; alignment is sometimes assumed for those cases. Sometimes alignment is demonstrated by asking SMEs to examine several content test forms and standards and judge whether content standards are covered adequately by the test forms. ACT Aspire has been involved in several SME-based alignment studies with each study demonstrating slightly different results depending on the standards examined and on the SMEs who participated.

Strong empirical evidence supports that ACT Aspire scores can be interpreted as measures of college and career readiness. ACT score scales for English, mathematics, reading, and science have been empirically linked to ACT Aspire scores and the ACT College Readiness Benchmarks, which relate scores on the ACT assessment directly to performance in college courses. ACT Aspire Readiness Benchmarks have been defined by working backward from student performance data that support inferences of a student being on target for readiness. An empirical link has also been established between the ACT Aspire Composite score and the ACT National Career Readiness Certificate (ACT NCRC), which provides information about student achievement and employable skills in reading, math, and locating information. These research-based connections to real-world college and career performance contribute direct evidence of alignment from ACT Aspire assessments to college and career readiness skills and knowledge. Therefore, ACT Aspire assessments exhibit strong alignment with college and career readiness standards.

ACT has a historical connection to the Common Core State Standards (CCSS), a set of academic standards adopted by many states. In 2008, the National Governors Association and the Council of Chief State School Officers invited ACT and other partners to help develop a set of research-supported college and career readiness standards. ACT provided data, empirical research, and staff expertise about what constitutes college and career readiness. Due to some of the shared research upon which the CCSS were based, significant overlap exists between them and the college and career readiness constructs used to guide the development of ACT Aspire.

ACT also contributed to the creation of the Next Generation Science Standards (NGSS) that many states have implemented. ACT science content experts presented ACT research on science curricula and career and college readiness with NGSS developers early in the NGSS drafting process.

Strong alignment between ACT Aspire and the NGSS exists; however, the ACT Aspire assessments are not designed specifically to assess the NGSS. As previously described, the ACT Aspire science assessments are based on ACT research on current curricula at the elementary, middle, and high school levels as well as ACT research on college and career readiness.

Some areas of achievement are not measured by ACT Aspire Summative Assessments. Specifically, any standards that require extended time, advanced uses of technology, active research, peer collaboration, producing evidence of a practice over time, or speaking and listening are not currently assessed on ACT Aspire Summative Assessments.

Further information on the alignment of ACT assessments can be found in the document “How ACT Assessments Align with State College and Career Readiness Standards,” available at https://www.act.org/content/dam/act/unsecured/documents/Alignment-White-Paper.pdf.

Chapter 2

# Test Development

## 2.1 Assessment Design Elements and Construct Coherence

ACT Aspire tests are designed to measure student achievement and progress toward college and career readiness. A principal philosophical basis for a longitudinal system of tests such as ACT Aspire is that readiness is best assessed by measuring, as directly and authentically as possible, the academic knowledge and skills that students will need in order to be successful. Coherence across the learning trajectory of college and career readiness constructs is required to support inferences about individual and aggregate growth. Skills and understanding develop over time, which means that students must learn new material and must also apply what they have previously learned in more sophisticated ways. ACT Aspire assessments are designed to measure key college and career readiness constructs in a way that recognizes that knowledge and skills are not isolated to specific grades, but rather should progress across grades. Items and tasks are designed to elicit evidence about constructs learned primarily in a particular grade, and also collect evidence about the skill progression across grades. From a measurement perspective, this design is an important component of supporting a vertical scale, thus reinforcing inferences about growth. Using this design is also important to develop actionable reports for students across all achievement levels.

Although measuring progress across grades occurs in all the subject tests, it can be illustrated most clearly by examining the design of the mathematics test. In each form, certain items contribute to Integrating Essential Skills (IES) scores. IES items are explicitly designed to elicit evidence about a concept that was introduced in a previous year but that the student must now apply in a more advanced context. An illustration of this from the mathematics test is provided in Chapter 3. These items are important for understanding where a student in the current grade actually falls on the learning trajectory.

The ACT Aspire assessments are designed to be developmentally and conceptually linked across grades. To clearly reflect and help interpret that link, the reporting categories are associated across all grades. The ACT Aspire scores are on the same vertical score scale for each subject. At higher grades, students taking the ACT Aspire are closest in age and skill development to students taking the ACT and ACT NCRC, and, therefore, these scores have an even stronger empirical bridge to inferring levels of college and career readiness.

## 2.1.1 ACT Aspire Item Types

The goal of assessment is to collect relevant evidence from the student as authentically as possible while sampling enough of the construct to support inferences based on the student's responses. ACT Aspire uses multiple item types to achieve this goal. The ACT Aspire assessments measure student knowledge and abilities in the following areas.

- Selected-response (SR) items require the examinee to select a single correct response among several provided choices.
- Constructed-response (CR) items require students to generate their own response to the questions.
- Technology-enhanced (TE) items incorporate computer interfaces to ask questions and pose scenarios that are not possible in traditional paper-based formats. TE items may require students to generate their responses, or they may present students with a set of answer options.

Each ACT Aspire test contains a combination of these item types. ACT Aspire English tests across all grades feature selected-response and TE items. The ACT Aspire writing tests feature only constructed response tasks (based on a single writing prompt). For the reading, mathematics, and science tests, each grade-level exam contains selected-response, constructed-response, and technology-enhanced items (selected-response items replace TE items on paper forms).

## 2.1.2 Cognitive Complexity and Depth of Knowledge (DOK)

The cognitive complexity level of written passages and the cognitive demands of an assessment item are important characteristics to consider when measuring a student's academic achievement. ACT Aspire assessments reflect the skills students are expected to have to think, reason, and analyze at high levels of cognitive complexity in order to be college and career ready; items and tasks target different levels of cognitive complexity, with most items targeted at upper levels. Due to the wide use of Norman Webb's depth-of-knowledge terminology, this document describes the cognitive complexity of items using language such as "depth of knowledge" (DOK).

Following to Webb's definition, DOK levels are assigned to reflect the complexity of the cognitive process required, not the psychometric "difficulty" of the item. ACT assigns a DOK level 4 value to describe only multiday, potentially collaborative classroom activities and assessments designed for learning purposes. By this definition, DOK ratings on any Summative Assessment completed in a single timed sitting (including ACT Aspire) are limited to values of 1 to 3.

Following Webb's framework, ACT applies DOK 1 to items that require students to recall and reproduce information. DOK 2 is applied to items that require mental processing that goes beyond recall--students apply skills and concepts. DOK 3 is applied to items that require strategic thinking: planning, explaining, justifying, using evidence, conjecturing, and postulating.

# 2.2 The ACT National Curriculum Survey

The ACT National Curriculum Survey is a one-of-a-kind nationwide survey, conducted by ACT every few years, of educational practices and college and career readiness expectations. ACT surveys thousands of K–12 teachers and college instructors in English/writing, mathematics, reading, and science, as well as national cross-section of workforce supervisors and employees, for the purpose of determining which skills and knowledge in these subjects are currently being taught at each grade level and which skills and knowledge are currently considered essential for college and career readiness.

Questions are also included about which skills from the ACT Holistic Framework®—a holistic, research-based framework that integrates behavioral skills, education and career navigation skills, and dimensions such as core academic skills and cross-cutting capabilities—are most integral to college and career success.

ACT uses the results of the ACT National Curriculum Survey to guide the development of ACT assessment solutions, including the ACT test, ACT Aspire®, and ACT WorkKeys®. ACT conducts the survey to ensure that its assessments are measuring the current knowledge and skills that instructors of credit-bearing, first-year college courses identify as important for success in each content area or that workforce supervisors identify as important for readiness for targeted workforce training and for success on the job.

ACT makes the results of each ACT National Curriculum Survey public to help education and workforce stakeholders make more informed decisions about the skills needed to be successful in postsecondary education and the workplace.

## An Integrated Framework for Education and Career Success

The ACT National Curriculum Survey is an essential tool in ACT's commitment to ensuring not only that the assessments are valid and relevant on a continuing basis, but also that they provide information enabling students and workers to be fully ready to embark successfully on rewarding college and career journeys.

## The Purpose of the ACT National Curriculum Survey

The ACT National Curriculum Survey is a crucial step in the process used to build and regularly update a valid suite of ACT assessments that is empirically aligned to college readiness standards. The survey directly informs the test blueprint for the assessments. Results from the assessments are used to validate ACT's College and Career Readiness Standards as well as its College and Career Readiness Benchmarks.

Equally important is predictive validity. Using actual course performance, ACT answers a second critical question: Does the test accurately and reliably predict performance? Constant monitoring allows ACT to ensure that the answer to both questions is "yes."

ACT periodically uses findings from the ACT National Curriculum Survey to monitor the test blueprints. This process ensures that the assessments always measure not only what is being taught in schools around the country, but also what demonstrably matters most for college and career readiness.To maintain relevancy and currency, it is important that assessments are built based on up-to-date evidence of what matters most according to the assessment contexts, assessment's purpose, and content being assessed.

The science behind ACT assessments—the evidence base and ongoing research—is critical to answering the key question of what matters most in college and career readiness. The ACT National Curriculum Survey represents ACT’s commitment to:

- use evidence and research to develop and validate ACT standards, assessments, and benchmarks;
- maintain a robust research agenda to report on key educational metrics (The Condition of College & Career Readiness, Enrollment Management Trends Report, The Reality of College Readiness, and The Condition of STEM); and
- develop assessments, reports, and interventions that will help individuals navigate their personal path to success along a kindergarten-through-career continuum.

Accordingly, the following principles have shaped and will continue to drive ACT's development agenda:

7. Report results in instructionally relevant ways that support clear interpretation within and across content areas.
8. Establish reasonable testing times by assessing what research and evidence show to be the most critical factors for success after high school.
9. Leverage technology to enhance student engagement, produce more meaningful results, and share results in a timely fashion.
10. Increase the emphasis on evidence-centered design, implementing best practices as they mature, and improve ACT's capabilities within the highest-quality design and development processes.
11. Include science as a core academic domain in ACT's assessment batteries.
12. Reflect the reality that there are multiple dimensions of readiness and success (validated by research).

As a nonprofit educational research organization, ACT will use these principles to drive the development and continuous improvement of ACT’s education and workplace solutions, as well as the research agenda associated with them, thereby enabling ACT to fulfill its mission of helping all individuals achieve education and workplace success.

## Survey Sample and Process

For the 2020 ACT National Curriculum Survey, ACT made online survey instruments available via various print and electronic methods (e.g., advertisements, email, social media) and invited participation from educators at the early elementary school, late elementary school, middle school, high school, and college levels who teach courses in English/writing, mathematics, reading (including English language arts and social studies), and science (including biology, chemistry, physics, and earth/space science) in public and private institutions across the United States. ACT also invited participation from supervisors and employees at a large variety of businesses. Table 2.1 gives the numbers of survey respondents in each area.

**Table 2.1 ACT National Curriculum Survey 2020 Respondents**

| Area | Number of Respondents |
|---|---|
| Early Elementary School | 1,214 |
| Late Elementary School | 1,213 |
| Middle School | 1,623 |
| High School | 1,619 |
| K-12 Administrators | 405 |
| College Instructors | 2,883 |
| Workforce Supervisors | 405 |
| Workforce Employees | 406 |
| TOTAL | 9,768 |

Education participants were asked to rate discrete content knowledge and skills with respect to how important each is to student success in the content area. (Specifically, K–12 teachers were asked to rate the importance of each content or skill in a given class they teach, while college instructors were asked to rate the importance of each content or skill as a prerequisite to success in a given class they teach.) ACT also asked the K–12 teachers to indicate whether or not they teach a particular content or skill and, if so, whether they teach it as a standard part of their course or as part of a review of material that should have been learned earlier. Some education participants were also asked other content-related questions depending on the grade level they teach.

Workforce participants were asked to rate discrete skills with respect to how important each is to entry-level success in the workplace. ACT also asked workforce participants to indicate how often employees in their workplace use each of these skills on the job.

Finally, ACT asked all participants a number of questions relevant to current education policy issues (e.g., assessments; technology; standards; student characteristics; and obstacles to success). These results are discussed in the companion report *ACT National Curriculum Survey 2020* (act.org/research).

Because some content areas were surveyed in larger numbers than others, the values displayed in educational-level totals were averaged across English language arts, mathematics, and science. This ensured that, in these results, no one content area would have more influence than another.

# 2.3 ACT Aspire Test Development Processes

## 2.3.1 Selecting and Training Item Writers

ACT chooses item writers who demonstrate adequate qualifications (e.g., practicing teachers, subject specialists, curriculum coordinators, department chairs). Item writers have extensive content and pedagogical knowledge and teach at the grades covered by ACT Aspire. These educators are actively engaged in teaching at various levels, at a variety of institutions, from small private schools to large public schools.

ACT recruits item writers who represent the diversity found in the United States with respect to ethnic background, gender, English-language proficiency, and geographic location.

Figure 2.1 illustrates the flow of item and test form development for ACT Aspire. The first three steps of this process are described in the following sections of this chapter, and steps 4–7 are described in subsequent chapters of this technical manual.

## 2.3.2 Designing Items That Elicit Student Evidence

Item writers are instructed to consider the entire construct when crafting assessment tasks and items. Items are designed to elicit evidence about students' knowledge and skills that span the full construct, which in many cases is beyond any specific achievement standard language. Item writers use templates that frame what knowledge, skills, and abilities are of greatest interest in construct measurement while calling out unintentional knowledge, skills, and abilities that should not be measured. Items must fulfill task model requirements (e.g., content, DOK, word count, accessibility), reflect diversity, and meet fairness standards.

The goal of crafting high-quality items or tasks is to create situations that collect relevant evidence from the student in a manner that is as authentic as possible while sampling enough of the construct to support the inferences based on the student's responses.

## 2.3.3 Item Review

All items undergo rigorous content reviews by internal and external content experts to ensure that they elicit sufficient student evidence, that they are developmentally appropriate, and that the contents and contexts are error-free. The process includes internal peer reviews, internal senior-level reviews, and external reviews. The content reviews also ensure that each item or task measures what is intended and functions at the intended DOK. External experts participate in fairness reviews to ensure that items and tasks are fair and not biased to one student demographic.

Initial forms are constructed to conform to test specifications. Once constructed, forms are reviewed by ACT staff and external content panelists. These panelists evaluate items for content accuracy and evaluate the test form for context appropriateness and representation. They also confirm that the form will collect the necessary evidence to support the intended inferences from scores.

After forms are finalized, they are administered operationally, and they are equated. Before students receive scores, data is carefully checked to ensure items and forms are working as intended.

## 2.3.4 Field Testing

ACT Aspire field testing follows an embedded model in which field-test items are spiraled across operational forms. All field-test items are prepared and delivered for administration within the same forms as the operational items. This model allows for field-test items to be delivered to some students with accommodations. There are no specific directions provided to students or test coordinators about field-test items, except that students and educators are alerted that some items may not count toward their overall score.

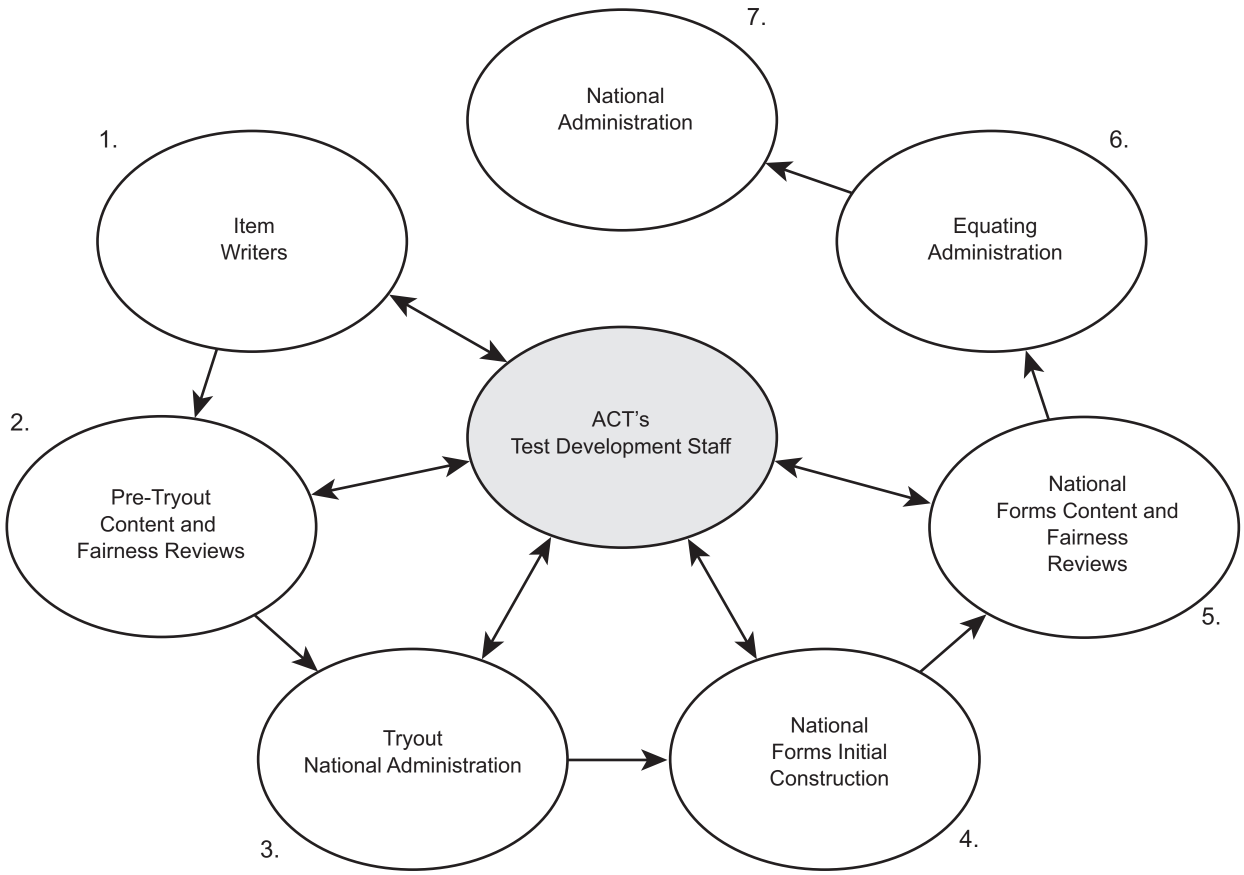


**Figure 2.1. Item and test development model.**

# Chapter 3

# Assessment Specifications

## 3.1 Overview

Each test includes a specified range of item types (i.e., selected response, constructed response, technology enhanced)[1] and a specified range of item difficulties at targeted depths of knowledge organized into content-specific reporting categories. The amount and nature of evidence needed to support an inference about a student's achievement about a given construct are taken into consideration when selecting the types and number of items developed for each reporting category. These requirements are balanced with maintaining manageable administration conditions. ACT Aspire assessments cover topic progressions from foundational concepts to sophisticated applications. Taken as individual subject tests or as a battery, ACT Aspire assessments can be delivered via computer or through a paper-and-pencil administration.

## 3.2 ACT Aspire Assessment Support Materials

### 3.2.1 ACT Knowledge and Skills Map

The ACT Knowledge and Skills Map is an interactive online tool that can be used to learn more about ACT's college and career readiness domain across grades. Each subject provides a grade-by-grade overview of knowledge and skills that research suggests a student should achieve on the path to college and career readiness. In addition to providing a framework for understanding the path to college and career readiness, the ACT Knowledge and Skills Map provides sample items and research citations.

http://skillsmap.actlabs.org/map

[1] On paper forms, technology enhanced items are replaced with selected-response items with similar content representation.

### 3.2.2 ACT Aspire Exemplar Items

ACT Aspire has developed two resources designed to help students, parents, educators, and policymakers become familiar with ACT Aspire test presentation and content. These resources, the Student Sandbox and the Exemplar Test Question Booklets, illustrate the different types of test questions and formats found in both paper-based and computer-based tests.

https://www.act.org/content/act/en/products-and-services/act-aspire/about-act-aspire/exemplar-items.html

## 3.3 English Language Arts Assessments Overview

The ACT Aspire English language arts (ELA) domain consists of subject tests in reading, writing, and English. The ELA assessments use text-based constructed-response, technology-enhanced, and selected-response tasks to  measure student achievement in the core components of ELA and literacy. Reported scores align with college and career readiness standards in ELA and literacy so that students, parents, and educators can understand performance on the test in terms that clearly relate to instruction.

Students who take ACT Aspire English, reading, and writing tests receive a composite ELA score that shows how their overall performance compares to the readiness benchmark at their grade. The benchmark is empirically based on performance linked to college and career readiness. The composite ELA score is reported in an effort to provide insight about student skills that are integrated across the English language arts. This perspective aligns with the integrated approach to literacy education in leading achievement standards frameworks.

### 3.3.1 English Test

The English test puts the student in the position of a writer who makes decisions to revise and edit a text. Short passages provide a variety of rhetorical situations. Students must use the rich context of the passage to make editorial choices, demonstrating their understanding of writing strategies and conventions of written English. Students must also apply understanding of how to maintain a consistent style and tone.

Figure 3.1 shows an example of the test reporting categories and targeted skills.

### 3.3.1.1 English Framework

The English framework articulates constructs measured across grades. Each grade lists descriptive statements of knowledge and skills measured within each reporting category. Please see Appendix A for more details.

### 3.3.1.2 English Reporting Categories

The English test measures student knowledge and skill in the following reporting categories.

### Production of Writing

Students apply their understanding of the rhetorical purpose and focus of a piece of writing to develop a topic effectively. They use various strategies to achieve logical organization, topical unity, and cohesion.

- Topic development: Students demonstrate understanding and control of the rhetorical aspects of texts by identifying the functions of parts of texts, determining whether a text has accomplished a purpose, and evaluating the relevance of material in terms of a text's focus.
- Organization, unity, and cohesion: Students use various strategies to ensure that a text is logically organized, flows smoothly, and has an effective introduction and conclusion.

### Knowledge of Language

Students demonstrate effective language use by ensuring precision and concision in word choice and maintaining consistency in style and tone.

### Conventions of Standard English

Students apply an understanding of the conventions of standard English grammar, usage, and mechanics to revise and edit text.

- Punctuation, Usage, and Capitalization Conventions: Students edit text to conform to standard English punctuation, usage, and capitalization.
- Sentence Structure and Formation: Students apply their understanding of relationships between and among clauses, placement of modifiers, and shifts in sentence construction.

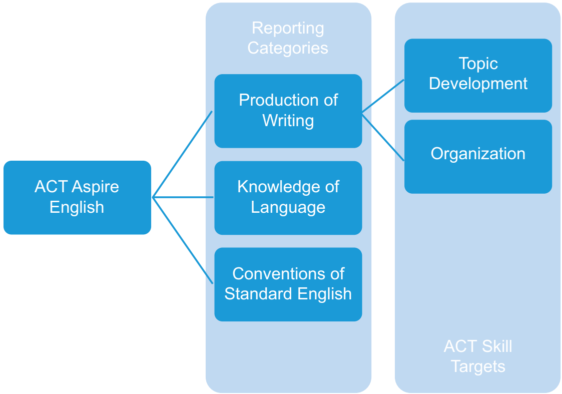


**Figure 3.1. ACT Aspire English test reporting with example skill targets for one reporting category**

### *3.3.1.3 English Item Types*

The test consist of texts (such as essays, sentences, and paragraphs), each accompanied by selected-response and, on computer-based forms, technology-enhanced items (on paper forms, technology-enhanced items are replaced by selected-response items). Different essay genres are employed to provide a variety of rhetorical situations. Texts vary in length depending on the grade. The stimuli are chosen not only for their appropriateness in assessing writing skills, but also to reflect students' interests and experiences. Some questions refer to underlined or highlighted portions of the essay and offer several alternatives to the portion underlined. These items include "NO CHANGE" to the underlined or highlighted portion in the essay as one of the possible responses. Some questions ask about a section of a paragraph or an essay, or about the paragraph or essay as a whole. The student must decide which choice best answers the question posed.

### *3.3.1.4 English Test Blueprints*

Tables 3.1-3.4 show the specification ranges for English at the different grades. Nonoperational items are included in the total number of items in the tables but do not contribute to raw-score points.

**Table 3.1. Specification Ranges by Item Type and Reporting Category for Grade 3**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 27–28 | 27–28 (87–90%) |
| Technology enhanced | 3–4* | 3–4 (10–13%) |
| Reporting Categories | | |
| Production of writing | 12–14 | 12–14 (39–45%) |
| Conventions of standard English | 17–19 | 17–19 (55–61%) |
| Nonoperational | | |
| Field test | 8 | |
| TOTAL: | 39** | 31 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.2. Specification Ranges by Item Type and Reporting Category for Grades 4–5**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 27–28 | 27–28 (87–90%) |
| Technology enhanced | 3–4* | 3–4 (10–13%) |
| Reporting Categories | | |
| Production of Writing | 8–10 | 8–10 (26–32%) |
| Knowledge of Language | 3–5 | 3–5 (10–16%) |
| Conventions of Standard English | 17–19 | 17–19 (55–61%) |
| Nonoperational | | |
| Field test | 8 | |
| TOTAL: | 39** | 31 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.3. Specification Ranges by Item Type and Reporting Category for Grades 6–8**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 31–33 | 31–33 (86–94%) |
| Technology enhanced | 2–4* | 2–4 (6–11%) |
| Reporting Categories | | |
| Production of Writing | 9–12 | 9–12 (26–34%) |
| Knowledge of Language | 3–6 | 3–6 (9–17%) |
| Conventions of Standard English | 19–21 | 19–21 (54–60%) |
| Nonoperational | | |
| Field-test | 10 | — |
| TOTAL: | 45** | 35 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.4. Specification Ranges by Item Type and Reporting Category for EHS**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 46–48 | 46–48 (92–96%) |
| Technology enhanced | 2–4* | 2–4 (4–8%) |
| Reporting Categories | | |
| Production of Writing | 13–14 | 13–14 (26–28%) |
| Knowledge of Language | 6–8 | 6–8 (12–16%) |
| Conventions of Standard English | 29–31 | 29–31 (58–62%) |
| Nonoperational | | |
| Field-test | 12 | — |
| TOTAL: | 62** | 50 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

# 3.3.2 Reading Test

The reading test measures a student's ability to read closely, reason about texts using evidence, and integrate information from multiple sources. Passages in the reading test include both literary narratives (such as prose fiction, memoirs, and personal essays) and informational texts from the natural sciences and social sciences. Across grades, these texts span a range of complexity levels that lead up to the reading level assessed on the ACT assessment. At each grade, passages at different complexity levels within an apprpriate range present students different opportunities to demonstrate understanding. Test items focus on the mutually supportive skills that readers use to understand and learn from texts. Items assess the student's reading ability at various depth of knowledge (DOK) levels. Items assess the student's reading ability at various depth of knowledge (DOK) levels. Items do not test the rote recall of facts from outside the passage or rules of formal logic, nor do they assess vocabulary without reference to the passage context.

Figure 3.2 shows an example of the test reporting categories and targeted skills.

## *3.3.2.1 Reading Framework*

The reading framework articulates constructs measured across the grades. Each grade has descriptive statements of knowledge and skills measured within each reporting category. Please see Appendix B for more details.

## *3.3.2.2 Reading Reporting Categories*

The reading test assesses skills in the following reporting categories.

## *Key Ideas and Details*

Students read texts closely, determine central ideas and themes, summarize information and ideas accurately, understand relationships, and draw logical inferences and conclusions, including understanding sequential, comparative, and cause-effect relationships.

## *Craft and Structure*

Students determine word and phrase meanings, analyze an author's word choice, analyze text structure, and understand authorial purpose and characters' points of view. Students interpret authorial decisions rhetorically and differentiate between various perspectives and sources of information.

## *Integration of Knowledge and Ideas*

Students understand authors' claims, differentiate between facts and opinions, and use evidence to make connections between different texts that are related by topic. Students read a range of informational and literary texts critically and comparatively, making connections to prior knowledge and integrating information across texts. Some items will require students to analyze how authors construct arguments, evaluating reasoning and evidence from various sources.

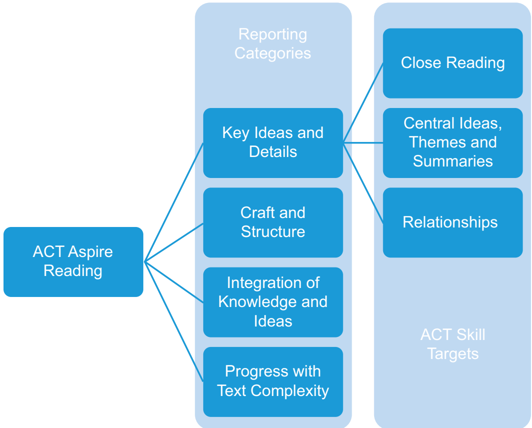


**Figure 3.2. ACT Aspire reading test reporting categories with example skill targets for one reporting category.**

## *3.3.2.3 Reading Test Complexity and Types of Texts*

During the development of the reading test, ACT evaluates the text complexity of reading passages in order to build assessments with a range of texts at the appropriate complexity level for each grade level.

Table 3.5 shows ACT Aspire's five levels of text complexity. These levels were established through ACT's research and validated through a review process that included ELA teachers. Together with tasks that target important reading skills at each grade, these complexity levels ensure a coherent progression across the assessment continuum. A sixth level of complexity, Highly Complex, is not included in the table because those passages are only administered on the ACT.

**Table 3.5. Passage Coverage by Text Complexity for the ACT Aspire Reading Test**

| | Grade Level | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| Basic | X | X | X | | | | |
| Straightforward | X | X | X | X | X | | |
| Somewhat challenging | | | X | X | X | X | X |
| More challenging | | | | | | X | X |
| Complex | | | | | | | X |

ACT research staff has analyzed the effect of text complexity on reading comprehension. Drawing on this research, ACT designed a measure that reports student performance on specific reading tasks that require comprehension and integration of information across texts. In addition to the overall reading score, each student receives this text complexity progress measure. While the overall reading score provides a measure of important comprehension skills, this score offers a focused measure of the skills that a reader uses to draw inferences, make connections, and integrate meaning across the challenging texts found in educational and workplace settings.

Performance on the text complexity progress measure is compared to a readiness level empirically derived from ACT College Readiness Benchmarks. Students who perform above the benchmark will receive an indication that they are making sufficient progress toward reading the complex texts they will encounter in college and career. Students who perform below the benchmark will receive recommendations for improvement such as practicing reading appropriately complex texts from a variety of genres, monitoring understanding, and using other strategies to comprehend literary and informational texts.

ACT Aspire Reading passages are drawn from the following text types:

- Literary narrative: Literary passages from short stories, novels, memoirs, and personal essays
- Social science: Informational passages on topics such as anthropology, archaeology, biography, business, economics, education, environmentalism, geography, history, political science, psychology, and sociology
- Natural science: Informational passages on topics such as anatomy, astronomy, biology, botany, chemistry, ecology, geology, medicine, meteorology, microbiology, natural history, physiology, physics, technology, and zoology

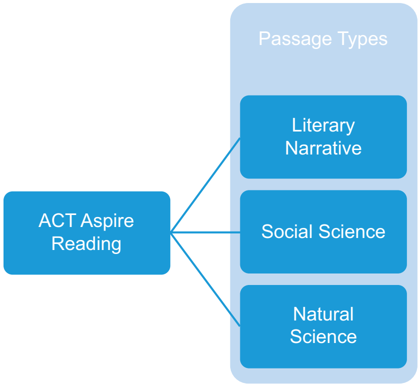


**Figure 3.3. ACT Aspire reading test passage types.**

## *3.3.2.4 Reading Item Types*

The reading test contains selected-response, constructed-response, and technology-enhanced items (on the CBT version).

Examples of constructed-response items in the reading test include the following:

- Making claims about a passage and providing support using specific details from the text
- Identifying similarities and differences between the key ideas of paired passages and providing support using specific details from both texts

Constructed-response items are scored according to rubrics that give students varying amounts of credit for responses that are correct or partially correct, enabling differentiation between multiple skill levels.

### 3.3.2.5 Reading Test Blueprints

The reading test has four sections in grades 3 through 5 and three sections in grades 6 through 10. Each section contains one prose passage that is representative of the level and kinds of text commonly encountered in school at that grade. Each passage is accompanied by a set of selected-response and constructed-response items, and, on computer-based forms, some sections include technology-enhanced items. Every test includes one constructed-response item that introduces a second, shorter passage on the same topic as the primary passage. These items require the student to synthesize information from across the texts.

Tables 3.6-3.8 show the specification ranges for the reading test at the different grades. Non-operational items are included in the total number of items provided in the tables but do not contribute to raw-score points.

**Table 3.6. Specification Ranges by Item Type and Reporting Category for Grades 3–5**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 19–21 | 19–21 (68–75%) |
| Technology enhanced | 1–3* | 1–3 (4–11%) |
| Constructed response | 2 | 6 (21%) |
| Reporting Categories | | |
| Key Ideas and Details | 13–15 | 13–17 (46–61%) |
| Craft and Structure | 6–8 | 6–10 (21–36%) |
| Integration of Knowledge and Ideas | 2–3 | 4–5 (14–18%) |
| Field-test | 7 | — |
| TOTAL | 31** | 28 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.7. Specification Ranges by Item Type and Reporting Category for Grades 6-7**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 19–21 | 19–21 (68–75%) |
| Technology enhanced | 1–3* | 1–3 (4–11%) |
| Constructed response | 2 | 6 (21%) |
| Reporting Categories | | |
| Key Ideas and Details | 13–15 | 13–17 (46–61%) |
| Craft and Structure | 6–8 | 6–10 (21–36%) |
| Integration of Knowledge and Ideas | 2–3 | 4–5 (14–18%) |
| Field-test | 8 | — |
| TOTAL | 32** | 28 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.

**Table 3.8. Specification Ranges by Item Type and Reporting Category for Grades 8–EHS**

| Operational Items | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 19–21 | 19–21 (63–70%) |
| Technology enhanced | 1–3* | 1–3 (3–10%) |
| Constructed response | 2 | 8 (27%) |
| Reporting Categories | | |
| Key Ideas and Details | 13–15 | 13–18 (43–60%) |
| Craft and Structure | 6–8 | 6–11 (20–37%) |
| Integration of Knowledge and Ideas | 2–3 | 5–6 (17–20%) |
| Nonoperational | | |
| Field-test | 8 | — |
| TOTAL | 32** | 30 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.9. Items by Passage Type for the ACT Aspire Reading Test**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| LN | 12 | 12 | 12 | 8 | 8 | 8 | 8 |
| INFO | 12 | 12 | 12 | 16 | 16 | 16 | 16 |

*Note*. LN = Literary Narrative (prose fiction, memoirs, personal essays); INFO = Informational Texts (social science and natural science)

# 3.3.3 Writing Test

The ACT Aspire writing test consists of a single timed minute writing task at each grade. The tasks target one of three primary modes of writing: reflective narrative, analytical expository, or persuasive argumentative. Students write an essay in response to a writing stimulus. The assessments are designed to provide an indication of whether students have the writing skills they will need to succeed at the next grade level. In grades 3-5, students have 45 minutes to complete the task, and in grades 6-EHS students have 40 minutes.

## *3.3.3.1 Writing Task Types by Grade*

Because there is one extended writing task at each grade, ACT Aspire rotates through the three modes to ensure coverage across grades.

The reflective narrative mode appears at grades 3 and 6. The analytical expository mode appears at grades 4, 7, and early high school. The persuasive/argumentative mode appears at grades 5 and 8. The ACT Aspire assessments are designed to give students at every grade an opportunity to display the higher-order thinking skills needed for meaningful reflection, analytical explanation, and persuasive argumentation.

**Table 3.10. Tasks by Writing Mode for Each Grade of the Writing Test**

| Grade | Writing Mode |
|---|---|
| 3 | Reflective Narrative |
| 4 | Analytical Expository |
| 5 | Persuasive Argumentative |
| 6 | Reflective Narrative |
| 7 | Analytical Expository |
| 8 | Persuasive Argumentative |
| EHS | Analytical Expository |
| ACT | Persuasive Argumentative |

### 3.3.3.2 Writing Scoring Rubrics and Reporting Categories

The writing test is scored with a four-domain analytic scoring rubric. Each grade has a unique rubric because the writing tasks assess different writing modes, but the underlying design is the same across grades.

Each of the four rubric domains corresponds to a different trait of the writing sample; traits in the writing sample are evidence of the following writing competencies:

#### Reflective Narrative/Analysis/Argument

The name of the first rubric domain corresponds to the mode of writing assessed at the grade. Regardless of the mode, this rubric domain is associated with the writer's generation of ideas. Scores in this domain reflect the ability to generate productive ideas and engage with the writing task. Depending on the mode, writers generate ideas to provide reflection, analysis, or persuasive and reasoned arguments. Competent writers understand the topic they are invited to address, the purpose for writing, and the audience. They generate ideas that are relevant to the situation.

#### Development and Support

Scores in this domain reflect the writer's ability to develop ideas. Competent writers explain and explore their ideas, supporting them with reasons, examples, and detailed descriptions. Their support is well integrated with their ideas. They help the reader understand their thinking about the topic.

#### Organization

Scores in this domain reflect the writer's ability to organize ideas with clarity and purpose. Competent writers arrange their writing in a way that clearly shows the relationship between ideas, and they guide the reader through their reflection, analysis, or argument about the topic.

#### Language Use

Scores in this domain reflect the writer's ability to use language to convey their ideas with clarity. Competent writers make use of the conventions of grammar and mechanics. Their word choice is precise, and they are also aware of their audience, adjusting voice and tone to enhance their purpose.

The reporting categories on the writing test correspond to the rubric domains.

**Table 3.11. Writing Test Scoring Rubric Domains and Associated Reporting Categories**

| Scoring Rubric Domain | Reporting Category |
|---|---|
| Reflective Narrative/Analysis/Argument (corresponds to writing mode) | Ideas and Analysis |
| Development | Development and Support |
| Organization | Organization |
| Language Use | Language Use and Conventions |

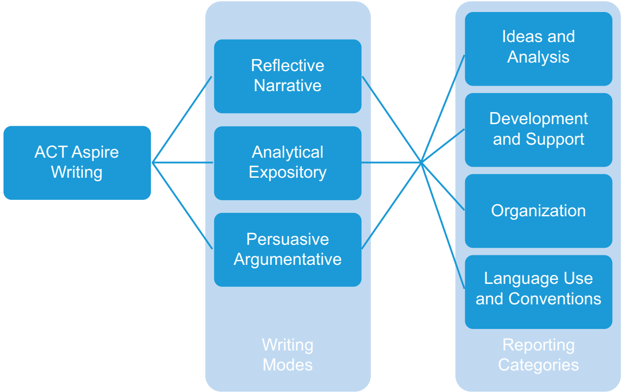


**Figure 3.4. ACT Aspire writing test modes and reporting categories.**

At grades 3 through 5, the rubrics have five performance levels; at grade 6 and above, the rubrics have six performance levels. At each grade and in each domain, a score of 4 is associated with adequacy, indicating that a student who achieves this score is on track for success in the next grade. In the five-point rubrics for grades 3 through 5 there is only one performance level above “adequate,” whereas there are two performance levels above adequate in the six-point rubric. A score of 5 at these grades indicates an advancing level of skill.

The analytic rubrics delineate four dimensions of writing, but traits are scored holistically within each domain. Descriptors within each domain are not intended to function as independent features assessed separately. Instead, scorers use those elements collectively to form a holistic evaluation of the student’s ability in that domain.

**Table 3.12. Points by Content Category for the Writing Test**

| | Raw-score points (percentage of test) | |
|---|---|---|
| Content Category | Grades 3-5 | Grades 6-EHS |
| Ideas and Analysis | 5 (25%) | 6 (25%) |
| Development and Support | 5 (25%) | 6 (25%) |
| Organization | 5 (25%) | 6 (25%) |
| Language Use and Conventions | 5 (25%) | 6 (25%) |
| TOTAL | 20 (100%) | 24 (100%) |

Further details about the writing rubrics for grades 3–EHS can be found in Appendix A.

# 3.4 Mathematics Test

The mathematics test measures the whole of a student's mathematical development, breaking it into progress with topics new to the grade and progress with lasting topics from previous grades. The mathematics test provides nine reporting categories, helping teachers, students, and parents identify areas of strength and areas to improve.

The ACT Aspire mathematics assessments emphasize quantitative reasoning frequently applied to real-world contexts. The mathematics test requires students to make sense of the problem, context, and notation; access appropriate mathematical knowledge from memory; incorporate the given information; do mathematical calculations and manipulations; interpret; apply thinking skills; provide justification; make decisions; and communicate results. Students are expected to know basic formulas and have basic computational skills, but they are not expected to memorize complex formulas nor perform lengthy computations.

The mathematical content assessed at a given grade is based on mathematical learning expectations up through that grade that are important to future college and career readiness. Tasks focus on what students can do with the mathematics they have learned, which encompasses not only content but also mathematical practices.

## 3.4.1 Mathematics Reporting Categories

Aspire structures the mathematics through early high school into 12 domains, described in the following paragraphs. Each domain represents a progression of topics for the grade band indicated in parentheses following the domain name. For each Aspire mathematics test, grade 3 through Early High School, the parts of these domains that correspond to the grade become a reporting category for the test. This results in 5 reporting categories for each test. The 5 reporting categories are also combined into an overall Grade Level Progress reporting category. In addition, the Integrating Essential Skills reporting category assesses a collection of lasting topics from previous grades, presented at the higher level of expectations of the current grade. Sometimes tasks will cut across these reporting categories, but for reporting purposes each task will be assigned to the most appropriate single reporting category. Supplemental reporting categories reflect the mathematical practice of Justification & Explanation and the mathematical practice of Modeling. All tasks involve some mathematical practices and so all scores reflect a combination of mathematical topics and practices.

## *Number & Operations in Base 10 (K–5)*

Starting from an understanding of the base 10 system involving 1s, 10s, and 100s, students extend to 100s, 1,000s, and further, working toward seeing connections between place values. Students use these connections to extend their number system to include decimals. Students can compute using place-value understanding, flexibly combining and decomposing groups. This thinking undergirds mental mathematics for one's lifetime, and being able to explain and critique strategies helps cement these important skills. Concurrently, students are seeing the need for efficient computation, and they understand and can explain the procedures they use. By the end of this grade band, students use place-value strategies fluently for mental arithmetic and explain their reasoning, and they compute fluently using efficient computation strategies with multidigit whole numbers and decimals to hundredths.

## *Number & Operations—Fractions (3–5)*

Students develop an understanding of several useful interpretations of fractions. There are connections from unit fractions to equal sharing, and representations of a whole broken into equal-size pieces. But fractions are also numbers, each with a place on the number line and a role in computation. Students compute with fractions (up through division with a unit fraction and a whole number) and understand how fraction computation is built on the properties of operations with whole numbers. They can explain why a step in a procedure is necessary.

## *The Number System (6–8)*

Students coming into this grade band have nearly finished extending whole-number operations to fractions, and they complete the task, understanding division of one fraction by another. Then the cycle continues: students extend the four operations to all rational numbers. Students understand the order of rational numbers, which now allows them to plot points in all four quadrants of the coordinate plane, and they understand absolute value in terms of distance. Students solve problems and use properties of the rational numbers to aid computation. They clearly tie their computations into their arguments and draw conclusions from conditional statements. Students can convert rational numbers to decimals and to fractions. But not all numbers are rational numbers, and by the end of this grade band, students understand that a number like $\sqrt{2}$ is not rational and can work with approximations.

## *Number & Quantity (EHS)*

Coming into high school, students have knowledge of the real-number system and have a strong understanding of and fluency with rational numbers and the four basic operations. They can work with irrational numbers by working with rational numbers that are close. Students are ready to move from integer exponents to rational exponents, and they are ready to probe a little deeper into properties of the real-number system. Later, students extend to complex numbers, which offer solutions to some simple equations that have no real-number solutions, and students learn to compute in this system. Students are invited to go further, exploring properties of complex numbers and therefore learning more about real numbers. Students explore vectors and matrices and learn to view them as number systems with properties, operations, and applications.

Throughout high school, students are maturing in their understanding of quantity and its connections to measurement. Attending to the types of quantities and units can guide solution strategies and help avoid errors. Students work with derived quantities, and when modeling they choose appropriate quantities to model.

## *Operations & Algebraic Thinking (K–5)*

Students bring an understanding of addition and subtraction as well as counting by 2s and 5s to this grade band. Students use this knowledge to develop an understanding of multiplication in terms of combining equal-size groups and of division as forming equal-size groups for sharing. Arrays and rectangular area provide models for multiplication and division, and from those connections, students learn about properties of operations, using those properties to aid in computation. Solving problems, working with factors and multiples, and learning in other domains all contribute to fluency with all four operations and the ability to explain reasoning.

Students use conditional statements (when that is true, then this is true) mainly with specific numbers but working toward general statements. Numerical expressions and equations capture calculations and relationships, and working with number patterns develops operational sense as well as moving toward the concept of function.

## *Expressions & Equations (6–8)*

This category is closely related to Ratios and Proportional Relationships and to Functions, building a foundation of algebraic understanding. Before this grade band, students routinely write numerical expressions. Now students routinely write expressions using a letter to represent a number and are working to attach meaning to expressions and to understand how the properties of numbers are useful for working with expressions. This starts with a study of how to generate equivalent expressions using properties of numbers and of what it means for expressions to be equivalent. Integer exponents represent very large and very small quantities, and later, students extend to rational exponents. Students understand what it means for a number to be a solution to an equation, and that solving an equation involves a process of reasoning about solutions, justified by the properties of numbers and operations. Linear equations are the focus, and students use graphs and equations to express relationships. Lines (except vertical lines) have a well-defined slope, and the concurrent geometric progress with similar triangles allows students to prove this. Students understand the connections between proportional relationships, lines, and linear equations. Reasoning about the solution of linear equations is applied to solve linear inequalities and to find simultaneous solutions of a pair of linear equations.

## Ratios & Proportional Relationships (6–7)

Proportional relationships are multiplicative relationships between quantities and are a step toward general linear relationships. Students coming into this grade band start with strong multiplication skills and expand the ways of working with “how many times as much?” comparisons, including ratios, rates, and percentages. They look at rate of change and connect unit rates with the slope of a graph, a pattern in a table, and a multiplier in an equation, using all forms of rational numbers. This builds to general understanding of function as input and output pairs and understanding of proportional functions and then linear functions. Functions are not tied to a specific representation: tables can show representative values, graphs can show behavior in a representative region, and equations can represent some types of functions. Linear equations $y = mx + b$ represent all linear functions. The Expressions and Equations domain provides ways of working with these equations. Linear functions are useful in modeling.

## Functions (8–EHS)

Functions have been with students since their early years: consider the counting function that takes an input of “seven” and gives “eight” and an input of “twelve” to give “thirteen.” In grade 8, the concept of function is named and becomes an object of study. Understanding some general properties of functions will equip students for problem solving with new functions they create over their continued studies and careers. Functions provide a framework for modeling real-world phenomena, and students compare functions and model relationships with functions.

## Algebra (EHS)

Students coming into high school build on their understanding of linear equations to make sense of other kinds of equations and inequalities: what their graphs look like, how to solve them, and what kinds of applications they have for modeling. Students develop fluency with algebra. They continue to make sense of expressions in terms of their parts in order to use their fluency with strategy and to solve problems. Through repeated reasoning, students develop general understanding of solving equations as a process that claims that all the solutions will be found. Students extend to quadratic equations, polynomial equations, rational equations, radical equations, and systems, integrating an understanding of solutions in terms of graphs. Families of equations have properties that make them useful for modeling. Solutions of polynomial equations are related to factors of a polynomial. Students recognize relationships in applications and create expressions, equations, and inequalities to represent problems and constraints.

## Geometry (K–EHS)

For grades 3–5, students start recognizing shapes in terms of attributes, which now makes for interrelated categories of shapes that share certain attributes (e.g., the category of parallelograms is made up of all shapes where each of the 4 sides is parallel to the opposite side). Squares make up a subcategory of parallelograms, so all the properties of parallelograms apply to squares. In general terms, the attributes of a category apply for all subcategories. Shapes can be made from points, lines or line segments, angles, and other shapes. Shapes can have lines of symmetry. Shapes can be decomposed, which has connections to fractions. All these concepts can be used to solve problems. Students can find examples and counterexamples. Toward the end of this grade band, students extend number-line concepts to the coordinate plane, plot points in the first quadrant, and make interpretations in real-world problems.

For grades 6–8, students focus on area, surface area, and volume. The additive property of area means the area of a polygon can be found by decomposing it into simpler figures the student already can find the area of. Through repeated reasoning, and in conjunction with the Expressions and Equations domain, students bring meaning to formulas for perimeter, circumference, area, surface area, and volume. They solve problems involving triangles, special quadrilaterals, and polygons, with attention to symmetry. Students work up to circles, cubes, right prisms, cylinders, cones, and spheres. Students develop the spatial reasoning to describe the cross section of three-dimensional figures sliced by a plane. Students address geometric distance. In the coordinate plane, they start plotting polygons and finding the length of horizontal and vertical sides. Later, they reach the Pythagorean theorem and its converse, justifying these relations and using them to solve problems in two and three dimensions and in a coordinate plane. They understand how to use scale. Students delve into creating figures that meet given conditions based on angle measures, lengths, and symmetry, noting when the conditions lead to a unique figure. This leads to the notion of congruence and then to similarity in terms of dilations, translations, rotations, and reflections. Students learn about these transformations and establish facts about, for example, angle sums in a triangle, and they use these facts to write equations and solve problems.

For EHS, building on their knowledge from grade 8, students add depth to what they know about transformations, reflections, rotations, and dilations and add precision to their understanding of congruence, similarity, and symmetry. Justification is the glue that holds structure together and lets students answer *why* questions, and students justify by using definitions and theorems, tying in calculations and diagrams, considering cases, understanding general versus specific statements, applying counterexamples, and putting statements together into coherent arguments. Students make constructions, solve problems, and model with geometric objects. Informal arguments give a chain of reasoning that leads to formulas for the area of a circle and then on to volume of cylinders, pyramids, and cones. Students solve right-triangle problems. All these results transfer to the coordinate plane, where analytic treatment of distance allows students to derive conditions for parallel and perpendicular lines, split a line segment into pieces with a given ratio of lengths, find areas, and develop equations.

## Measurement & Data (K–5)

These topics provide mutual reinforcement with topics from other domains including unit conversions related to scaling and multiplication, and whole numbers and fractions related to measurement and operations. Students solve problems that involve units and conversions, starting with time. They have a framework for measurement and can work with measurements as data for line plots and scaled picture graphs, and they can interpret these displays during problem solving. Students develop the concepts of perimeter and area through measurement and relate these to multiplication and addition, moving on to the concept of volume with its relationships to measurement, multiplication, and addition. Students understand angle measure and connect this to fractions of a circle.

## Statistics & Probability (6–EHS)

For grades 6–8, statistics is about distributions of quantities—like the amount of electricity used by each home in Anchorage, Alaska, last month—and how to tell how likely something is given what is known about the shape of the distribution and being sure to take into account the context of the data and the data-gathering process. Students have already graphed distributions, but now they pay more attention to the shape of the distribution, particularly where it seems to be centered and how spread out it is. Box plots capture some of the differences between distributions in a way that makes comparison surer. Students make informal inferences and learn about randomness in sampling. Probability is a language for conveying likelihood, and students develop uniform probability models and develop probability models from empirical data. They can use lists, tables, tree diagrams, and simulation results to represent sample spaces and estimate the probability of compound events.

For EHS, students add to their understanding of distributions of a single quantity, describing center and spread with statistics and interpreting these in the context of the data. Before high school, students used two-way tables and scatterplots to look at relationships between different quantities and used linear functions to model relationships that look linear. Now students pay more attention to informal model fit and use other functions to model relationships, use models for prediction, and interpret characteristics of the model in the context of the data. From two-way tables, students interpret relative probabilities (including joint, marginal, and conditional relative frequencies but not tied to these terms) and relate these to probabilities. Students look for association and distinguish correlation and causation.

Randomness unlocks the power of statistics to estimate likelihood, and students learn about the role of randomness in sample surveys, experiments, and observational studies. Students use data to estimate population mean or proportion and make informal inferences based on their maturing judgment of likelihood. They can compare qualities of research reports based on data and can use simulation data to make estimates and inform judgment.

Before high school, students tacitly used independence, but now the idea is developed with a precise definition. Students relate the sample space to events defined in terms of “and,” “or,” and “not” and calculate probabilities, first using empirical results or independence assumptions.

Figure 3.5 shows the general flow of the mathematical domains across the grades.

**Test Content Specifications and Flow: Mathematics**

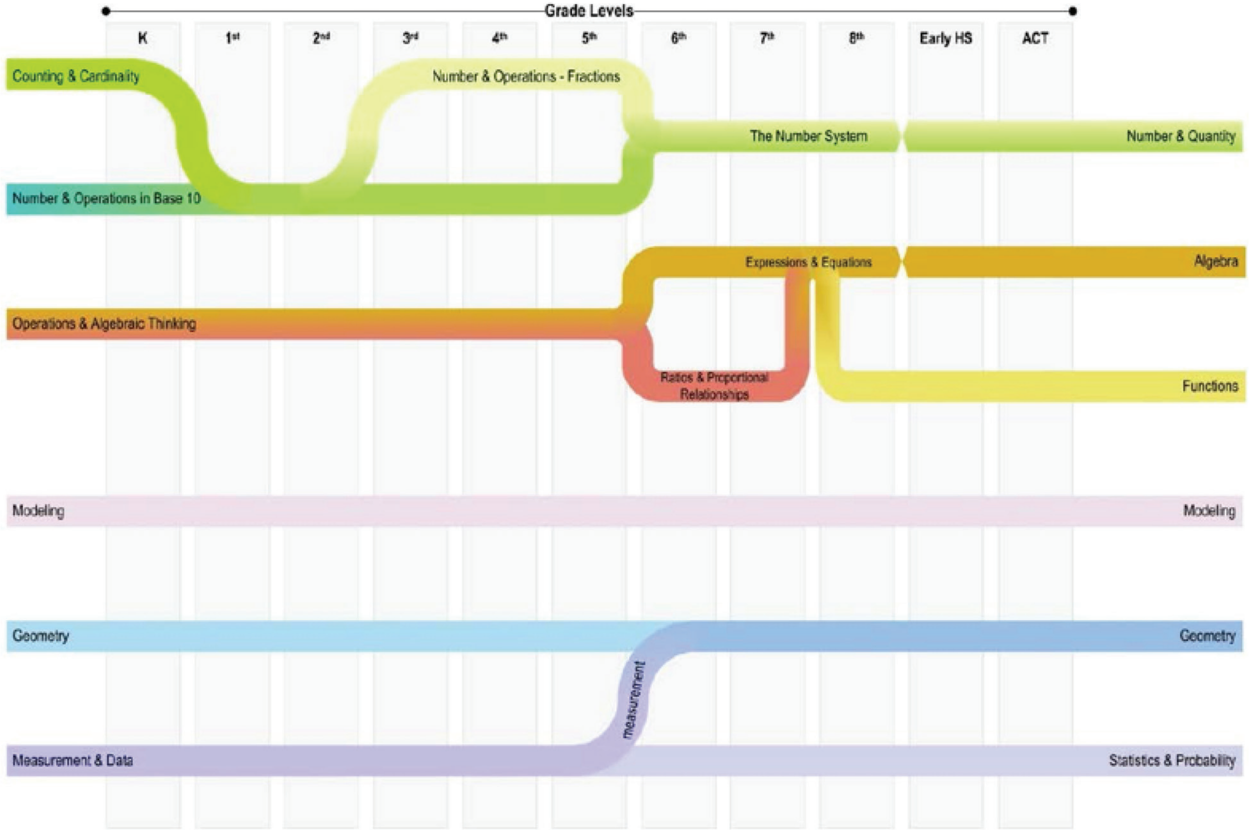


**Figure 3.5. Mathematics domains, and primary currents in the flow across grades.**

For each grade, assessment of student progress within the 5 domains of topics new to the grade is complemented by assessment of student progress with lasting topics from previous grades. Not only should students retain what they learned in previous grades, they should strengthen and integrate their learning and what they can do with those topics.

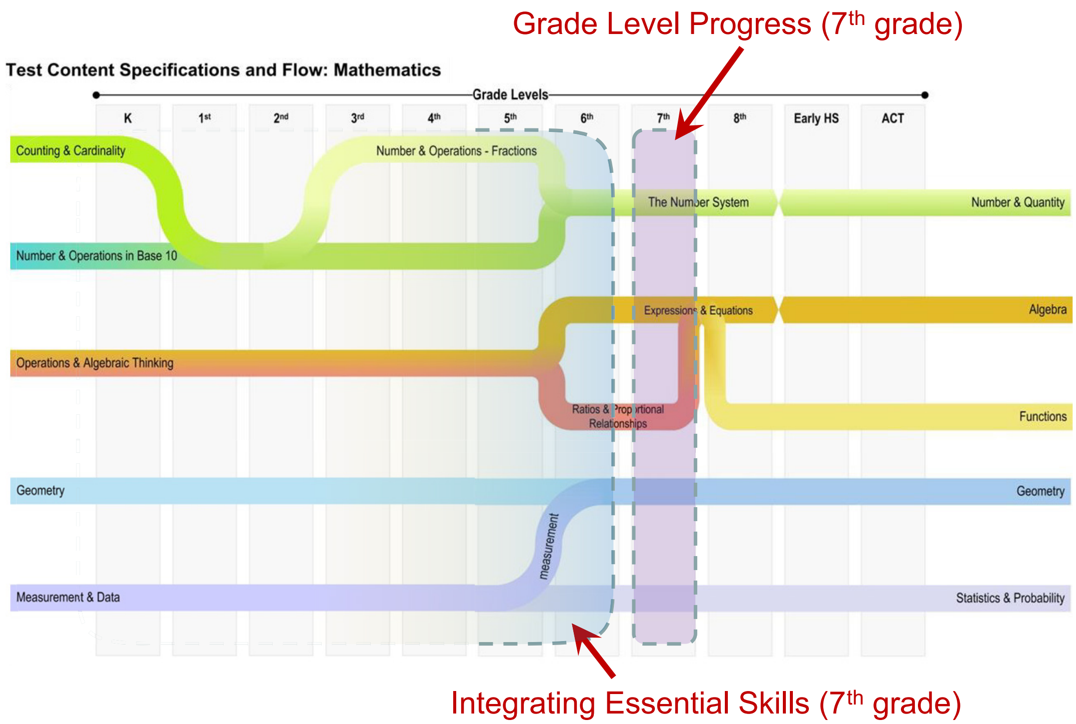


**Figure 3.6. Integrating essential skills and grade level progress (illustrated for grade 7).**

Progress with topics new to a grade is reflected in the Grade Level Progress reporting category. Progress with lasting topics from previous grades is reflected in the Integrating Essential Skills reporting category. Figure 3.6 shows how these components fit together. The sampling within the Grade Level Progress component is done to create a reporting category around each of the five domains of topics new to the grade. This additional layer of detail contributes greater precision to support insights about students.

## *Mathematical Practices*

Mathematical practices highlight cross-cutting mathematical skills and understandings and the complex and vital ways these skills integrate with content. Test items focus on important mathematics, which includes various levels of using mathematical practices, from basic understanding to sophisticated reasoning. Selecting items for a form involves including a diversity of mathematical topics as well as a diversity of mathematical practices.

In addition to assessing mathematical practices as a general part of scores, ACT Aspire reports on two important mathematical practices: Justification & Explanation and Modeling.

## Justification & Explanation

Justification & Explanation tasks focus on the whys of mathematics. ACT Aspire directly measures how well students function with mathematical argument, as appropriate for the given grade, using a constructed-response format. Each task involves Justification & Explanation as it applies to some mathematical content. Scores across three Justification & Explanation tasks are reported so that students and teachers can look in more depth at this important mathematical practice and how it is developing in each student. The tasks also contribute to the Grade Level Progress reporting category or to the Integrating Essential Skills reporting category according to the mathematical content involved. Each of the three Justification & Explanation tasks on each form is worth 4 raw-score points. This is captured in Table 3.13 by grade.

**Table 3.13. Number of Justification and Explanation Tasks, Raw-Score Points (and Percentage Weight) in Reporting Categories by Grade**

| | Grade | | |
|---|---|---|---|
| Justification & Explanation (JE) | 3–5 | 6–7 | 8–EHS |
| JE tasks overall | 3 | 3 | 3 |
| JE weight overall | 12 pts (31%) | 12 pts (27%) | 12 pts (24%) |
| JE tasks in Grade Level Progress | 1 | 1 | 1 |
| JE weight in Grade Level Progress | 4 pts (17%) | 4 pts (15%) | 4 pts (13%) |
| JE tasks in Integrating Essential Skills | 2 | 2 | 2 |
| JE weight in Integrating Essential Skills | 8 pts (50–53%) | 8 pts (44%) | 8 pts (40%) |

EHS = Early High School

The Justification & Explanation rubric, for all grades, is based on a single progression of Justification & Explanation skills, providing a connected measure of progress from grade to grade. The skills are divided into three levels at each grade, but these groupings differ depending on the grade. The most advanced skills in a grade are at level 3. Some Justification & Explanation skills at level 3 for grade 3 become level 2 skills in later grades, and some skills at level 2 become level 1 skills in later grades.

Justification & Explanation tasks for a grade are designed to elicit evidence that skills are at level 2 or level 3. Most tasks that elicit Justification & Explanation skills at a given level will also elicit Justification & Explanation skills at all lower levels.

## Modeling

Modeling involves two objects: the actual and the model. A model often helps one predict or understand the actual. The Modeling reporting category includes items that involve producing, interpreting, understanding constraints of, evaluating, and improving models.

There are a minimum number of raw-score points specified for a form for Modeling. Table 3.14 shows the minimum number by grade. Table 3.15 and Table 3.16 show the actual average number for two forms, and the actual average percentage for those two forms, respectively.

**Table 3.14. Modeling Minimum Number (and Percentage) of Raw-Score Points by Reporting Category and Grade**

| | Grade | | |
|---|---|---|---|
| Modeling | 3–5 | 6–7 | 8–EHS |
| Minimum number (percentage) of raw-score points overall | 7 (18%) | 9 (20%) | 11 (22%) |
| Minimum number (percentage) in Grade Level Progress | 5 (21%) | 6 (22%) | 7 (23%) |
| Minimum number (percentage) in Integrating Essential Skills | 2 (13%) | 3 (17%) | 4 (20%) |

*Note*. Percentages are rounded

**Table 3.15. Modeling Actual Average Number of Raw-Score Points for Two Forms by Grade**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| Modeling | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| Average number of raw-score points | 16 | 13 | 15 | 17.5 | 17.5 | 21.5 | 20.5 |
| Average number in Grade Level Progress | 10.5 | 9 | 8 | 13 | 10 | 12.5 | 11.5 |
| Average number in Integrating Essential Skills | 5.5 | 4 | 6 | 4.5 | 7.5 | 9 | 9 |

*Note*. Percentages are rounded

**Table 3.16. Modeling Actual Average Percentage of Raw-Score Points for Two Forms by Grade**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| Modeling | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| Average percentage overall | 43% | 35% | 39% | 38% | 38% | 41% | 41% |
| Average percentage in Grade Level Progress | 46% | 39% | 29% | 46% | 36% | 38% | 35% |
| Average percentage in Integrating Essential Skills | 39% | 29% | 43% | 25% | 42% | 45% | 45% |

*Note*. Percentages are rounded

## 3.4.2 Calculator Policy

Students taking the mathematics test for grade 6 or higher are encouraged to bring a calculator they are familiar using and can use fluently. A calculator tool is available in the online version; students are still encouraged to bring a calculator. Students are permitted to use most 4-function, scientific, or graphing calculators. The ACT calculator policy for ACT Aspire is available at www.act.org.

## 3.4.3 Mathematics Item Types, Tasks, and Stimuli

The mathematics test uses a specified variety of item types to collect appropriate evidence. Table 3.16 shows the percentage of raw-score points that come from each item type. These percentages reflect targets and may vary slightly.

**Table 3.17. Target Percentage of Raw-Score Points by Item Type and Grade**

| | Grade | | |
|---|---|---|---|
| Item Type | 3–5 | 6–7 | 8–EHS |
| Technology Enhanced* | 13% | 13% | 12% |
| Selected response | 56% | 60% | 65% |
| Constructed Response (Justification & Explanation) | 31% | 27% | 24% |

*Note*. Percentages are rounded
*Technology-enhanced items are replaced with selected-response items for the paper-based test.

### *Item Sets*

Some items are part of a set, which presents a common stimulus used for all the items in the set. Test items in the set are independent of one another, meaning that getting the correct answer to one item does not hinge on getting the correct answer to another item. Each form has approximately two item sets, with two to five items in each set. Items may be technology enhanced, selected response, or constructed response.

## 3.4.4 Mathematics Test Blueprints

The mathematics test is composed of different item types (i.e., selected response, technology enhanced, and constructed response). There are some nuances to be aware of across delivery modes (i.e., computer and paper) and within reporting categories.

Table 3.19 shows a range of numbers of items. The reporting category specifications are based on points, not on numbers of items. Items for Justification & Explanation and Modeling are included in the item counts in Grade Level Progress and Integrating Essential Skills. Non-operational items are included in the total number of items but do not contribute to raw-score points.

**Table 3.18. Specification Ranges by Item Type and Reporting Category for Grades 3–5**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| **Item Types** | | |
| Selected response | 21–23 | 21–23 (54–59%) |
| Technology enhanced* | 4–6 | 4–6 (10–15%) |
| Constructed response (Justification & Explanation) | 3 | 12 (31%) |
| **Reporting Categories** | | |
| Grade Level Progress** | 20–21 | 23–24 (59–62%) |
| Number & Operations in Base 10 | 3–5 | 3–5 (8–13%) |
| Number & Operations—Fractions | 4–5 | 4–5 (10–13%) |
| Operations & Algebraic Thinking | 3–6 | 3–6 (8–15%) |
| Geometry | 3–4 | 3–4 (8–10%) |
| Measurement & Data | 3–4 | 3–4 (8–10%) |
| Integrating Essential Skills** | 9–10 | 15–16 (38–41%) |
| Justification & Explanation | 3 | 12 (31%) |
| Modeling | ≥7 | ≥7 (≥18%) |
| **Nonoperational Items** | | |
| Field-test | 5 | – |
| TOTAL | 35** | 39 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper based test.
**The Grade Level Progress reporting category contains 1 of the Justification & Explanation items, worth 4 raw-scaroe points; the Integrating Essential Skills reporting category contains 2 of the Justification & Explanation items, worth 8 raw-score points.
***Total number of items includes field-test items that do not contribute to score points.

**Table 3.19. Specification Ranges by Item Type and Reporting Category for Grades 6–7**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 26–28 | 26–28 (58–62%) |
| Technology enhanced* | 5–7 | 5–7 (11–16%) |
| Constructed response (Justification & Explanation) | 3 | 12 (27%) |
| Reporting Categories | | |
| Grade Level Progress** | 24 | 27 (60%) |
| The Number System | 4–5 | 4–5 (9–11%) |
| Expressions & Equations | 5–6 | 5–6 (11–13%) |
| Ratio & Proportion Reasoning | 4–5 | 4–5 (9–11%) |
| Geometry | 3–4 | 3–4 (7–9%) |
| Statistics & Probability | 3–4 | 3–4 (7–9%) |
| Integrating Essential Skills** | 12 | 18 (40%) |
| Justification & Explanation | 3 | 12 (27%) |
| Modeling | ≥9 | ≥9 (≥20%) |
| Nonoperational Items | | |
| Field-test | 6 | – |
| TOTAL | 42*** | 45 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper based test.
**The Grade Level Progress reporting category contains 1 of the Justification & Explanation items, worth 4 raw-scaroe points; the Integrating Essential Skills reporting category contains 2 of the Justification & Explanation items, worth 8 raw-score points.
***Total number of items includes field-test items that do not contribute to score points.

**Table 3.20. Specification Ranges by Item Type and Reporting Category for Grade 8**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| **Item Types** | | |
| Selected response | 32–34 | 32–34 (63–67%) |
| Technology enhanced* | 5–7 | 5–7 (10–14%) |
| Constructed response (Justification & Explanation) | 3 | 12 (24%) |
| **Reporting Categories** | | |
| Grade Level Progress | 28 | 31 (61%) |
| The Number System | 2–3 | 2–3 (4–6%) |
| Expressions & Equations | 6–7 | 6–7 (12–14%) |
| Functions | 5–6 | 5–6 (10–12%) |
| Geometry | 6–7 | 6–7 (12–14%) |
| Statistics & Probability | 3–4 | 3–4 (6–8%) |
| Integrating Essential Skills | 14 | 20 (39%) |
| Justification & Explanation | 3 | 12 (24%) |
| Modeling | ≥11 | ≥11 (≥22%) |
| **Nonoperational Items** | | |
| Field-test | 6 | – |
| TOTAL | 48*** | 51 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper based test.
**The Grade Level Progress reporting category contains 1 of the Justification & Explanation items, worth 4 raw-scaroe points; the Integrating Essential Skills reporting category contains 2 of the Justification & Explanation items, worth 8 raw-score points.
***Total number of items includes field-test items that do not contribute to score points.

**Table 3.21. Specification Ranges by Item Type and Reporting Category for EHS**

| Operational Items | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 32–34 | 32–34 (63–67%) |
| Technology enhanced* | 5–7 | 5–7 (10–14%) |
| Constructed response (Justification & Explanation) | 3 | 12 (24%) |
| Reporting Categories | | |
| Grade Level Progress** | 28 | 31 (61%) |
| Number & Quantity | 2–3 | 2–3 (4–6%) |
| Algebra | 6–7 | 6–7 (12–14%) |
| Functions | 5–6 | 5–6 (10–12%) |
| Geometry | 6–7 | 6–7 (12–14%) |
| Statistics & Probability | 3–4 | 3–4 (6–8%) |
| Integrating Essential Skills** | 14 | 20 (39%) |
| Justification & Explanation | 3 | 12 (24%) |
| Modeling | ≥11 | ≥11 (≥22%) |
| Nonoperational Items | | |
| Field-test | 6 | – |
| TOTAL | 48*** | 51 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper based test.
**The Grade Level Progress reporting category contains 1 of the Justification & Explanation items, worth 4 raw-scaroe points; the Integrating Essential Skills reporting category contains 2 of the Justification & Explanation items, worth 8 raw-score points.
***Total number of items includes field-test items that do not contribute to score points.
Note that for the EHS level, topics new to Grade 8 are included in the GLP reporting category and not the Integrating Essential Skills reporting category. This reporting organization groups topics together, particularly algebra topics, for more coherence in score interpretation.

# 3.5 Science Test

The ACT Aspire science assessments are designed based on research evidence about what students need to know and do in science in order to be successful in college and career.

National Curriculum Survey (NCS) results show that educators at all levels, from elementary through postsecondary, report that science is better assessed using a science test rather than a reading, writing, or math test. Testing reading in science is important and aligns with most college and career readiness state standards related to literacy, and because of that, reading in science is assessed on the ACT Aspire reading test. However, because science is a unique learning domain, only the ACT Aspire science test questions contribute to students' science scores.

## 3.5.1 Science Reporting Categories

The science test assesses science knowledge, skills, and practices across three domains:

- Interpretation of Data
- Scientific Investigation
- Evaluation of Models, Inferences, and Experimental Results

The knowledge, skills, and practices contained in these domains compose the ACT College and Career Readiness Standards for science (and in the ACT and ACT Aspire Knowledge and Skills Domain, which are shown in Table 3.23), which link specific skills and knowledge to quantitatively determined score ranges for the ACT science test and a benchmark science score that is predictive of success in science in college. Like on the ACT science test, all items on the ACT Aspire science tests are based on authentic scientific scenarios that are built around important scientific concepts and are designed to mirror the experiences of real students and scientists. Some of the items require discipline-specific content knowledge (e.g., for EHS, knowledge specific to an introductory middle school biology course), but science content is always assessed in concert with science skills and practices. ACT's research on science curricula and instruction at the high school and post-secondary levels shows that while science content is important, science skills and practices are more strongly tied to college and career readiness in science.

The content of the ACT Aspire science tests includes the life sciences (biology), physical sciences (chemistry and physics), and the Earth/space sciences (e.g., geology, astronomy, and meteorology). Advanced knowledge in these areas is not required, but background knowledge acquired in grade-level science courses may be needed to correctly respond to some of the items in the upper-grade assessments. The assessments do not, however, sample specific content knowledge with enough regularity to make inferences about a student's attainment of content knowledge in any broad area, or specific part, of the science content domain. The science tests stress science practices over recall of scientific content, complex mathematics skills, or reading ability. When a science test is taken with the mathematics test, scores from the two tests are combined to provide a STEM (science, technology, engineering, mathematics) score.

## 3.5.2 Continuum of Complexity

Scientific scenarios are categorized along two dimensions on ACT Aspire: mode and complexity. Different modes focus on different aspects of science (e.g., scientific data/results, experimentation, and debate).

Complexity is determined by several factors that contribute to how challenging a scientific scenario is likely to be for a student. ACT Aspire focuses on five factors in particular: the topic (e.g., weather, photosynthesis rates), the tone (i.e., formality), the nature of the presented data (i.e., the density, content, and structure of graphs, tables, charts, and diagrams), and the difficulty of the embedded concepts (i.e., the introduced and assumed concepts, symbols, terminology, units of measure, and experimental methods). These elements combine in various proportions to result in scenarios of different complexity, and this complexity affects suitability for different grades.

This complexity also affects the difficulty of questions and tasks students are asked to perform in a given context (e.g., an easy question can become much more difficult when posed in a more challenging context).

The science test development process and item design is informed by science education research in learning progressions and misconceptions. This research informs the item task designs and test designs to assure that science knowledge, skills, and practices are tested at developmentally appropriate times and in appropriate ways at increasing levels of sophistication from grade 3 through EHS. Core skills and practices are similar across the grade continuum because our research shows that these skills and practices should be taught early and continually refined as a student progresses through school. What differs most from grade to grade in the science test is the complexity of the contexts in which science knowledge, skills, and practices are assessed. The contexts used on the tests place the students in rich and authentic scientific scenarios that require that the student apply their knowledge, skills, and practices in science to both familiar and unfamiliar situations. With increasing grade, the scenarios have increasingly complex scientific graphics and experimental designs and are based on increasingly complex concepts. The students must then apply their knowledge, skills, and practices with increasing levels of sophistication. The amount of assumed discipline-specific science content knowledge a student needs to answer questions on the tests also increases. Figure 3.7 illustrates this continuum.

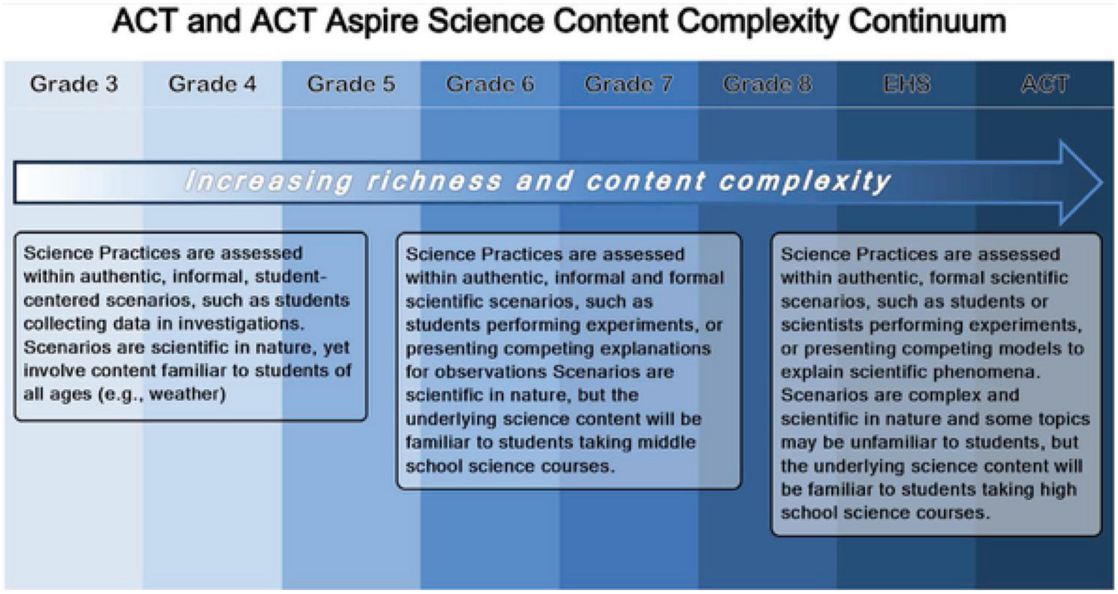


**Figure 3.7. ACT and ACT Aspire science content complexity continuum.**

# 3.5.3 Science Item Types

ACT Aspire science items require students to apply what they have learned in their science classes to novel, richly contextualized problems. The test collects evidence about students' ability to, for example, evaluate the validity of competing scientific arguments, scrutinize the designs of experiments, or find relationships in the results of those experiments. Technology-enhanced items provide various ways to collect unique evidence about how students engage with scientific material. To fully cover this complexity continuum, six different stimulus (passage) modes are employed across the science test, which vary from grade 3 through EHS. These include modes focused on data interpretation, scientific experimentation, or scientific debate.

Table 3.21 shows how many passages from which stimulus modes are used at each grade.

## *Conflicting Viewpoints*

This passage format is used in grades 8 and EHS in which two or more differing scientific explanations or arguments on the same topic are given, sometimes with one or more graphs, tables, or diagrams. Items focus on understanding the explicit and implicit points of each explanation, comparing and contrasting the explanations, drawing conclusions from the arguments, and evaluating the validity of the arguments.

## *Research Summaries*

This passage format is used for grades 7–EHS and involves a detailed experimental procedure along with one or more graphs, tables, or diagrams for experimental setups and results. (Technology enhancements involve gathering the data by manipulating variables.) Items focus on understanding aspects of experimental design or accompanying procedures, obtaining and analyzing data, and drawing conclusions from the data.

## *Data Representation*

This passage format is used for grades 6–EHS. A brief description is given for one or more graphs, tables, or diagrams. Items focus on obtaining and analyzing data and drawing conclusions from the data. Technology enhancements include videos, animations, and data manipulations (e.g., moving data points to affect a trend).

## *Student Viewpoints*

This passage format is used for grades 6 and 7 and is analogous to Conflicting Viewpoints but with one to three brief and simple explanations or arguments that support an observation (e.g., students may have differing interpretations of a data set or teacher demonstration). Items focus on understanding the explicit and implicit points of an argument, drawing conclusions from an argument, and evaluating the validity of an argument.

## Science Investigations

This passage format is used for grades 3–7 and is analogous to Research Summaries but is shorter and simpler. It includes more student-centered experimental procedures along with one to two graphs, tables, or diagrams for experimental setups and results. Items are focused on understanding aspects of experimental design and accompanying procedures, obtaining and analyzing data, and drawing conclusions from the data.

## Data Presentation

This passage format is used for grades 3–5 and is analogous to Data Representation, but data sources are simpler (and rarely more than two per unit) and more related to everyday life, with briefer descriptions. Technology enhancements include videos and animations.

**Table 3.22. Stimulus Modes Used on the ACT Aspire Science Test**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| Stimulus Mode | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| Conflicting Viewpoints | | | | | | 1 | 1 |
| Research Summaries | | | | | 1 | 2 | 2 |
| Data Representation | | | | 1 | 1 | 2 | 2 |
| Student Viewpoints | | | | 1 | 1 | | |
| Science Investigation | 2 | 2 | 2 | 2 | 1 | | |
| Data Presentation | 2 | 2 | 2 | | | | |

**Table 3.23.** The ACT and ACT Aspire Science Knowledge and Skill Domain

| | Skill Area | Skill Code | Skill Statement | College & Career Readiness Standards |
|---|---|---|---|---|
| Interpretation of Data (IOD) | Locating and Understanding | IOD-LU-01 | Select one piece of data from a data presentation | IOD 201, 401 |
| | | IOD-LU-02 | Find information in text that describes a data presentation | IOD 203, 303 |
| | | IOD-LU-03 | Select two or more pieces of data from a data presentation | IOD 301, 401 |
| | | IOD-LU-04 | Identify features of a table, graph, or diagram (e.g., axis labels, units of measure) | IOD 202 |
| | | IOD-LU-05 | Understand common scientific terminology, symbols, and units of measure | IOD 302 |
| | Inferring and Translating | IOD-IT-01 | Translate information into a table, graph, or diagram | IOD 403 |
| | | IOD-IT-02 | Determine how the value of a variable changes as the value of another variable changes in a data presentation | IOD 304, 503 |
| | | IOD-IT-03 | Compare data from a data presentation (e.g., find the highest/lowest value; order data from a table) | IOD 402, 502 |
| | | IOD-IT-04 | Combine data from a data presentation (e.g., sum data from a table) | IOD 501, 601, 701 |
| | | IOD-IT-05 | Compare data from two or more data presentations (e.g., compare a value in a table to a value in a graph) | IOD 501, 601, 701 |
| | | IOD-IT-06 | Combine data from two or more data presentations (e.g., categorize data from a table using a scale from another table) | IOD 501, 601, 701 |

**Table 3.23.** The ACT and ACT Aspire Science Knowledge and Skill Domain—continued

| | Skill Area | Skill Code | Skill Statement | College & Career Readiness Standards |
|---|---|---|---|---|
| | | IOD-IT-07 | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) | IOD 504, 602 |
| | Extending and Reevaluating | IOD-ER-01 | Perform an interpolation using data in a table or graph | IOD 404, 603 |
| | | IOD-ER-02 | Perform an extrapolation using data in a table or graph | IOD 404, 603 |
| | | IOD-ER-03 | Analyze presented data when given new information (e.g., reinterpret a graph when new findings are provided) | IOD 505, 702 |
| Scientific Investigation (SIN) | Locating and Comparing | SIN-LC-01 | Find information in text that describes an experiment | SIN 201, 303 |
| | | SIN-LC-02 | Identify similarities and differences between experiments | SIN 404 |
| | | SIN-LC-03 | Determine which experiments utilized a given tool, method, or aspect of design | SIN 405 |
| | Designing and Implementing | SIN-DI-01 | Understand the methods, tools, and functions of tools used in an experiment | SIN 202, 301, 302, 402 |
| | | SIN-DI-02 | Understand an experimental design | SIN 401, 403, 501 |
| | | SIN-DI-03 | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) | SIN 601 |
| | | SIN-DI-04 | Evaluate the design or methods of an experiment (e.g., possible flaws or inconsistencies; precision and accuracy issues) | SIN 701 |
| | Extending and Improving | SIN-EI-01 | Predict the results of an additional trial or measurement in an experiment | SIN 502 |
| | | SIN-EI-02 | Determine the experimental conditions that would produce specified results | SIN 503 |
| | | SIN-EI-03 | Determine an alternate method for testing a hypothesis | SIN 602 |
| | | SIN-EI-04 | Predict the effects of modifying the design or methods of an experiment | SIN 702 |

**Table 3.23.** The ACT and ACT Aspire Science Knowledge and Skill Domain—continued

| | Skill Area | Skill Code | Skill Statement | College & Career Readiness Standards |
|---|---|---|---|---|
| | | SIN-EI-05 | Determine which additional trial or experiment could be performed to enhance or evaluate experimental results | SIN 703 |
| Evaluation of Models, Inferences, and Experimental Results (EMI) | Inferences and Results: Evaluating and Extending | EMI-IE-01 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation or piece of information in text | EMI 401, 601 |
| | | EMI-IE-02 | Determine which experimental results support or contradict a hypothesis, prediction, or conclusion | EMI 505 |
| | | EMI-IE-03 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with two or more data presentations and/or pieces of information in text | EMI 501, 701 |
| | | EMI-IE-04 | Make a prediction and explain why it is consistent with two or more data presentations and/or pieces of information in text | EMI 401, 601 |
| | | EMI-IE-05 | Explain why presented information, or new information, supports or contradicts a hypothesis or conclusion | EMI 502, 702 |
| | | EMI-IE-06 | Make a prediction and explain why it is consistent with two or more data presentations and/or pieces of information in text | EMI 501, 701 |
| | Models: Understanding and Comparing (Grade 6 and higher) | EMI-MU-01 | Find information in a theoretical model (a viewpoint proposed to explain scientific observations) | EMI 201 |
| | | EMI-MU-02 | Identify implications and assumptions in a theoretical model | EMI 301, 402 |
| | | EMI-MU-03 | Determine which theoretical models present or imply certain information | EMI 302, 403 |
| | | EMI-MU-04 | Identify similarities and differences between theoretical models | EMI 404 |

**Table 3.23.** The ACT and ACT Aspire Science Knowledge and Skill Domain—continued

| | Skill Area | Skill Code | Skill Statement | College & Career Readiness Standards |
|---|---|---|---|---|
| (Grade 6 and higher) | Models: Evaluating and Extending | EMI-ME-01 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model | EMI 401, 601 |
| | | EMI-ME-02 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with two or more theoretical models | EMI 501, 701 |
| | | EMI-ME-03 | Identify the strengths and weaknesses of theoretical models | EMI 503 |
| | | EMI-ME-04 | Determine which theoretical models are supported or weakened by new information | EMI 504 |
| | | EMI-ME-05 | Determine which theoretical models support or contradict a hypothesis, prediction, or conclusion | EMI 505 |
| | | EMI-ME-06 | Use new information to make a prediction based on a theoretical model | EMI 603 |
| | | EMI-ME-07 | Explain why presented information, or new information, supports or weakens a theoretical model | EMI 602 |
| | | EMI-ME-08 | Make a prediction and explain why it is consistent with a theoretical model | EMI 401, 601 |
| | | EMI-ME-09 | Make a prediction and explain why it is consistent with two or more theoretical models | EMI 501, 701 |

# 3.5.4 Science Test Blueprints

The tests present several sets of scientific information, each followed by a number of test items. The scientific information is conveyed in one of six different formats (as described in section 3.5.3)

Tables 3.24–3.26 show the makeup of the ACT Aspire science tests for each grade. Technology-enhanced items are replaced by selected-response items on paper forms. Non-operational items were included in the total number of items but do not contribute to raw-score points.

**Table 3.24. Specification Ranges by Item Type and Reporting Category for Grades 3–5**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| **Item Types** | | |
| Selected response | 25–26 | 25–26 (69–72%) |
| Technology enhanced | 2–3* | 2–3 (6–8%) |
| Constructed response | 4 | 8 (22%) |
| **Reporting Categories** | | |
| Interpretation of Data | 16–21 | 18–22 (50–61%) |
| Scientific Investigation | 5–8 | 7–9 (19–25%) |
| Evaluation of Models, Inferences, and Experimental Results | 5–8 | 7–9 (19–25%) |
| **Nonoperational Items** | | |
| Field-test | 6 | – |
| TOTAL | 38** | 36 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.25. Specification Ranges by Item Type and Reporting Category for Grades 6–7**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| **Item Types** | | |
| Selected response | 29–30 | 29–30 (73–75%) |
| Technology enhanced | 2–3* | 2–3 (5–8%) |
| Constructed response | 4 | 8 (20%) |
| **Reporting Categories** | | |
| Interpretation of Data | 18–21 | 20–22 (50-55%) |
| Scientific Investigation | 4–9 | 6–10 (15–25%) |
| Evaluation of Models, Inferences, and Experimental Results | 8–11 | 10–12 (25–30%) |
| **Nonoperational Items** | | |
| Field-test | 6 | – |
| TOTAL | 42** | 40 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.26. Specification Ranges by Item Type and Reporting Category for Grade 8**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 29–30 | 29–30 (73–75%) |
| Technology enhanced | 2–3* | 2–3 (5–8%) |
| Constructed response | 4 | 8 (20%) |
| Reporting Categories | | |
| Interpretation of Data | 16–19 | 18–20 (45–50%) |
| Scientific Investigation | 6–9 | 8–10 (20–25%) |
| Evaluation of Models, Inferences, and Experimental Results | 10–13 | 12–14 (30–35%) |
| Nonoperational Items | | |
| Field-test | 8 | — |
| TOTAL | 44** | 40 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

**Table 3.27. Specification Ranges by Item Type and Reporting Category for EHS**

| | Number of Items | Raw-score points (percentage of test) |
|---|---|---|
| Item Types | | |
| Selected response | 29–30 | 29–30 (73–75%) |
| Technology enhanced | 2–3* | 2–3 (5–8%) |
| Constructed response | 4 | 8 (20%) |
| Reporting Categories | | |
| Interpretation of Data | 14–17 | 16–18 (40–45%) |
| Scientific Investigation | 8–11 | 10–12 (25–30%) |
| Evaluation of Models, Inferences, and Experimental Results | 10–13 | 12–14 (30–35%) |
| Nonoperational Items | | |
| Field-test | 8 | — |
| TOTAL | 44** | 40 (100%) |

*Technology-enhanced items are replaced with selected-response items for the paper-based test.
**Total number of items includes field-test items that do not contribute to score points.

# Chapter 4

# Item and Task Scoring

## 4.1 Selected-response Item Scoring

Selected-response items require students to select a correct answer from several alternatives. Each correct selected-response item has a value of 1 point. Incorrect, missing responses (items that a student did not answer) and multiple responses have a value of zero points.

## 4.2 Technology-Enhanced Item Scoring

Technology-enhanced items require students to make decisions about how to correctly answer questions. Some TE items require more than one decision or action. All TE items are dichotomously scored (a correct response is 1 point; an incorrect or missing response is zero points).

## 4.3 Constructed-Response Item Scoring

Initially, student responses to a constructed-response task are read and scored by trained raters. Training materials for scoring constructed-response tasks are created during range finding. Range finding involves test development specialists, content experts, and expert raters previewing student responses to determine whether the content-specific scoring criteria for each task accurately reflect and encompass all the acceptable student responses. The initial round of range finding also includes analysis and validation of the scoring rubrics used across tasks. Once the tryout tasks are scored, they undergo statistical analysis focusing on difficulty, validity, and accessibility to determine whether they are suitable for operational use. During range finding, a few student responses are individually rated by multiple raters using the scoring criteria and the appropriate rubric. Responses that do not receive the same score from all raters are discussed by the entire group until a consensus is reached. Additions and clarifications to the scoring criteria can be made at this time, if necessary.

After test development specialists and expert raters have completed range finding, responses are sorted and put together into training sets. Training materials include an anchor set, multiple practice sets, and at least two qualification sets that prospective raters must score accurately in order to be eligible to score field-test responses.

Responses chosen for the anchor set represent clear examples of each score. Practice set and qualification set responses also include clear examples of each score as well as responses that are not as perfectly aligned to the scoring criteria; these responses are less straightforward and fall either slightly high or low within each score point, making them challenging to score.

Each response included in the training materials is analyzed during range finding. A rationale explaining why a particular score was assigned accompanies the response. The rationale explains how the rubric and scoring criteria were used to determine the score; citations from the exemplar response are included, where appropriate, to illustrate the claims made in the articulation.

## 4.3.1 Performance Scoring Quality Control

### *4.3.1.1 Scorer Qualifications and Experience*

Scoring quality starts with recruitment and extends through screening and placement (assigning scorers to items based on their skills and experience), training, qualification, and scoring.

Priority is given to scorers with previous experience in scoring similar assessments. In most cases, these professional scorers have specialized educational and professional experience, including valuable experience in performance scoring. All scorers have, at a minimum, a four-year college degree.

The pool of scorers typically reflects a cross section in terms of age, ethnicity, and gender, but placement and retention of scorers is based on their qualifications and the quality and accuracy of their scoring.

### *4.3.1.2 Managing Scoring Quality*

Scorer exception processing is used at defined intervals to check scorer accuracy. Scorers who fall below predetermined standards receive automatically generated messages that interrupt their scoring and direct them to work with a scoring supervisor to review anchor papers or take other steps to improve their scoring accuracy.

Validity responses are prescored responses interspersed in the pool of live responses in order to gauge scorer accuracy. These responses are indistinguishable from live responses. Scores are compared to the true scores assigned by scoring supervisors and do not factor into final student scores in any way. This validity mechanism provides an objective and systematic check of accuracy. It verifies that scorers are applying the same standards throughout the project and, therefore, guards against scorer drift and ultimately group drift.

Backreading is the primary tool for proactively guarding against scorer drift. Scoring supervisors review responses to confirm that the scores were correctly assigned and to give customized feedback and remedial training to individual scorers. Backreading scores will override the first score.

Frequency distribution reports show a breakdown of scores assigned on a given task. Expressed in percentages, data in these reports show how often scorers, individually and as a group, assign each score. A project may have general expectations for frequency distribution ranges, which are typically based on historical data.

Ten percent of ACT Aspire CR student responses will be read and scored independently by two different scorers. Second scoring allows scoring supervisors to closely monitor the performance of scorers, though these scores do not contribute to a student's final reported score. Supervisors will use the second scores to provide scoring inter-rater reliability statistics and monitor scorer performance.

Inter-rater reliability is the agreement between the first and second scores assigned to student responses. Inter-rater reliability measurements include exact, adjacent, and nonadjacent agreement. Scoring supervisors use inter-rater reliability statistics as one factor in determining the needs for continuing training and intervention on both individual and group levels.

The electronic scoring system is capable of purging the scores assigned by a scorer whose work is deemed substandard. Scoring supervisors can reset scores by individual scorer, date range, or item, where the scores assigned by an individual are cleared from the database and the affected responses are reset. The responses are then randomly rerouted to qualified scorers and rescored according to the original scoring design.

Reports used to monitor quality and project completion status are generated and updated automatically and are available to scoring supervisors at any time via the digital scoring system. The reports give daily and cumulative statistics and provide individual and group average agreement percentages. Table 4.1 summarizes the reports.

Calibration sets are used to reinforce range-finding standards, communicate scoring decisions, or correct scoring issues and trends. The primary goal of calibration is to continue training and reinforce the scoring standards. Calibration set responses may be "on the line" between scores, or they may contain unusual examples that are challenging to score, and therefore useful for reinforcing the scoring rubric.

**Table 4.1. Scorer Performance Reports**

| Report Name | Description |
|---|---|
| Daily/Cumulative Inter-Rater Reliability Summary | Group-level summary of both daily and cumulative inter-rater reliability statistics for each day of the scoring project. |
| Frequency Distribution Report | Task-level summary of score distribution percentages on both a daily and a cumulative basis. |
| Daily/Cumulative Validity Summary | Summary of agreement for validity reads of a given task on both a daily and a cumulative basis. |
| Completion Report | Breakdown of the number of responses scored and the number of responses in each stage of scoring (first score, second score, resolution). |
| Performance Scoring Quality Management Report | Summary of task-level validity and inter-rater reliability on a daily and cumulative basis. This report also shows the number of resolutions required and completed, and the task-level frequency distribution. |

# 4.3.2 Automated Scoring

Combining human and artificial intelligence (AI) scoring provides an effective and efficient process for scoring student responses while maintaining scoring quality.

For ACT Aspire CR items in writing, science, and reading, ACT provides a combined human and AI approach to scoring. ACT trains an automated scoring engine on responses collected during the field test to determine which items can be satisfactorily scored using automated scoring. Rigorous statistical measures are used to ensure that the scores provided by each item's automated scoring calibration are comparable to, and interchangeable with, human scores. This entails comparing human and automated scores by exact agreement, Quadratic Weighted Kappa correlation, and Conditional Agreement by Scorepoint. Automated scoring is only used for an item if the item's calibration passes the established performance benchmarks for these key calibration approval criteria.

To provide an effective and efficient solution the goal is for the CR responses to be scored using automated scoring as the first score with a 10% second score by human scorers.

## *Overview of the Automated Scoring Process*

Automated scoring for ACT Aspire uses a machine-learning approach in which the engine is trained to score based on the collective wisdom of trained human scorers. Using a sample of human-scored student responses, the engine learns the different features that human scorers evaluate when scoring a response and how they weigh and combine those features to produce a score. The process begins with several hundred to one thousand or more human-scored student responses. The collection of student responses is divided into two sets: one set to train and tune the scoring engine and the other to validate performance.

The performance of automated scoring depends on both the sample of student responses available and the performance of human scorers. The goal is to have as much accurate information as possible about how a response should be evaluated. Pearson's human scorers double-score the field-test responses and resolve nonadjacent disagreements to fully support automated scoring. Having double-scored human responses is critical. First, double-scoring provides more information about the quality of a constructed response that can be used when training the automated scoring engine. Knowing that a response is on the cusp between two score points, a high 2 or a low 3, for example, provides a more complete picture of the score range. Second, double-scoring provides a measure of human performance against which automated scoring performance can be evaluated.

## *Involving Humans in the Automated Scoring Process*

Humans play a key role in maintaining quality throughout the scoring process, even when automated scoring is used. Not only do human scorers select the responses to train the scoring engine, but human scorers also double-score 10% of the responses in order to provide an additional quality check of the engine. Human scoring is still monitored through increased validity distribution through supervisor backreading—key indicators of scoring accuracy.

If human scores differ from the automated scoring engine, an expert human scorer reviews the response to resolve the discrepancy.

Finally, if the automated scoring engine determines it cannot score a response, that response is routed to a human scorer. This is particularly useful with responses that appear to be off-topic, not English, highly unusual, or creative.

## *Training the Automated Scoring Engine*

To learn to score essays, the automated scoring engine incorporates a range of machine learning and natural language processing technologies to evaluate the structure, style, and content of writing in the responses. The automated scoring engine uses a variety of semantic analysis techniques to generate semantic similarity of words and passages by analyzing large bodies of relevant text. The automated scoring engine can then "understand" the meaning of text much the same as a human reader.

Figure 4.1 illustrates some of the features used by the automated scoring engine to identify key components of student writing performance.

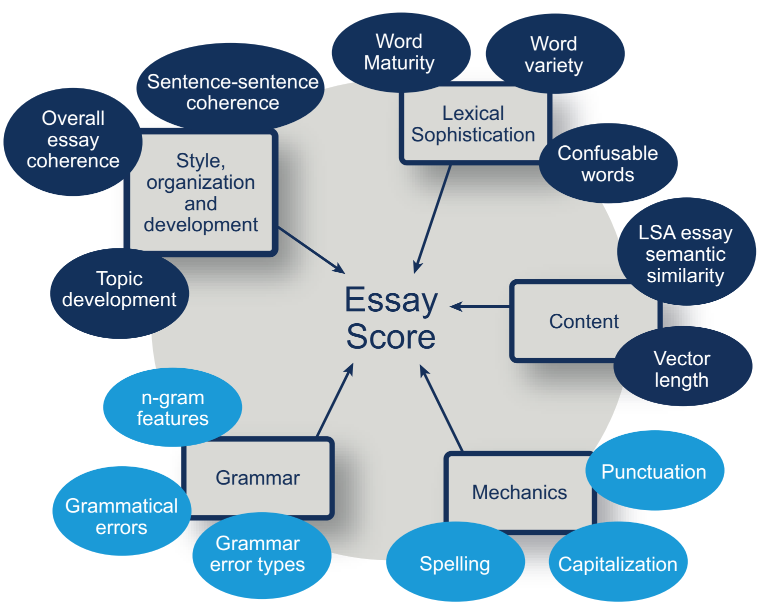


**Figure 4.1. Components of student writing performance.**

To evaluate an essay's development, audience, content, and organization, the automated scoring engine derives semantic models of English based on a statistical analysis of large volumes of text. For essay scoring applications, it is trained on a collection of text that is equivalent to the reading a student is likely to have done over the course of their academic career (about 12 million words).

Because semantic analysis operates over the semantic representation of texts, rather than at the word level, the engine is able to evaluate similarity even when texts have few words in common. For example, semantic analysis finds the following two sentences to have a high semantic similarity despite having no words in common:

> *Surgery is often performed by a team of doctors.*
>
> *On many occasions, several physicians are involved in an operation.*

Semantic analysis allows the automated scoring engine to compare a new response against a large set of prescored responses, using the scores of the most similar responses to help determine the score of the new response. This comparison is similar to the approach that human scorers take when evaluating responses. Human scorers are trained on anchor papers of annotated student responses with agreed-on scores. Human scorers compare new responses against the anchor set to determine the appropriate score.

The automated scoring engine scores responses similarly, except that it is able to make comparisons against a much larger set of examples. Rather than comparing a new response against a set of 16–24 examples in an anchor set, for example, it compares against the set of hundreds or thousands of responses on which it was trained. It is thus able to take advantage of a much wider range of examples that have been scored and validated. The machine uses all the training and knowledge that goes into human scoring and the methods that are used to monitor and maintain human scoring quality.

## *Role of Automated Scoring*

Automated scoring is used in a carefully calculated combination with human scoring of the constructed-response items to reduce scoring turnaround times and lead to more rapid reporting, while still maintaining scoring reliability and consistency.

## *Enhancing Human Scoring with an Automated System*

AI technology enhances human scoring rather than replacing it. In the traditional scoring model, two human scorers assess each essay. In an AI model, the scoring engine applies one score and a human applies a second score to 10% of essays.

## *Consistent Results with Artificial Intelligence Scoring*

The automated scoring engine has been used in a variety of assessment settings over two decades to score responses written by regular education students, English learners, and students with disabilities. Indeed, automated scoring can isolate and evaluate different aspects of an essay without bias. As a result, students who express good ideas, but perhaps do not use standard English, can still be rewarded for their ideas.

# Chapter 5

# Accessibility

ACT Aspire uses a variety of levels of accessibility support including universal supports, designated supports, English learner (EL) supports, and full accommodations to allow students with disabilities to participate in testing. For more information about ACT Aspire accommodations, see the *ACT Aspire Accessibility Supports Guide*.

## 5.1 Development of the ACT Aspire Accessibility Support System

The Standards for Educational and Psychological Testing (AERA, APA, & NCME, 2014) address fairness in testing as the central concern posed by the threat to validity known as measurement bias. The Standards specify two major concepts that have emerged in the literature for minimizing such bias: universal design and accessibility. Universal design is defined as “an approach to test design that seeks to maximize accessibility for all intended examinees” (p. 50). Accessibility is defined as “the notion that all test takers should have an unobstructed opportunity to demonstrate their standing on the construct(s) being measured” (p. 49).

The development of all ACT Aspire accessibility supports follow a theory of action known as *access by design* (Fedorchak, 2013) which incorporates into its conceptual structure elements of universal design for learning (UDL) described by the Center for Applied Special Technologies (CAST, 2011) and Evidence Centered Design (Mislevy, Almond, & Loves, 2004; Mislevy & Haertel, 2006).

Universal design is necessary, but alone it is not sufficient to meet the needs of every learner (UDL Guidelines, Version 2.0, Principle III, 2011). Multiple means of engagement are required. To meet this requirement, ACT designed a structured data-collection procedure, called accessibility feature mapping, to build a system of accessibility supports. This system is intended to meet the needs of diverse learners while maintaining the validity of the assessment. The development team conducted a detailed analysis of every passage and item to determine which accessibility supports could be provided for seven diverse learner populations that would fully honor the constructs being measured. The data collected from this process informed the accessibility policy and support system for ACT Aspire. (The ACT Aspire levels of support resulting from this procedure are described more fully in section 5.2.)

The development team created a chart for every item in every form for all audio-scripted ACT Aspire items. Every feature within each item (passage, stem, equations, graphics, interaction type, etc.) was examined to see how each contributed to the

1. constructs being measured and the
2. cognitive performance demands of the item (presentation demands, interaction and navigation demands, response demands, and general test demands).

For each of seven targeted learner populations (see Figure 5.1), access pathways to the item (either already available or identified as needed by the analysis) were identified and compared with targets to ensure that all access pathways did not violate the intended construct of the item. The components of this procedure are shown below.

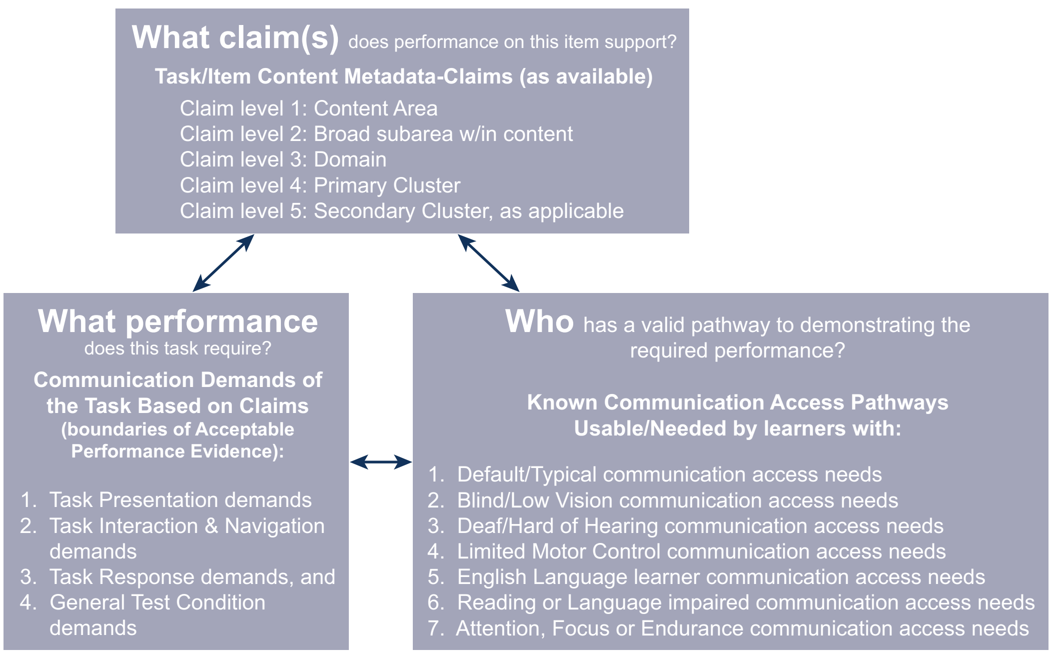


**Figure 5.1. Accessibility feature-mapping process.**

# 5.2 Test Administration and Accessibility Levels of Support

All accessibility supports permitted during ACT Aspire testing and described in the *ACT Aspire Accessibility Supports Guide* are designed to remove unnecessary barriers to student access to the assessments. Based on the feature-mapping development process that incorporated the targeted construct definitions, all permitted supports fully honor the content, knowledge, and skills the tests measure.

## 5.2.1 Understanding Levels of Accessibility Support

While the term *accessibility* often refers to the needs of students with disabilities or limited English proficiency, accessibility is not restricted to any one group of students. Accessibility is a universal concept that describes the need everyone has, regardless of an established label, to access products and services. The term *accommodations* describes only one intensive level of accessibility support.

Over the last decade in educational research and practice we have come to understand that all students have tools they need and use every day to engage in the classroom and effectively communicate what they have learned. (See the References section later in this manual.) Individual students may need different levels of support to demonstrate what they know and can do in an academic setting, including standardized testing.

ACT Aspire permits the use of supports that will honor the skills and knowledge that the tests measure, while removing construct-irrelevant barriers to student performance. The multiple levels of supports represent a continuum from the least-intensive supports (universal support tools) to the most-intensive supports (modifications). Modifications are not permitted on ACT Aspire assessments because these would change what the test is designed to measure. This accessibility supports system assumes all users have needs that fall somewhere on this continuum.

These accessibility supports

- allow all students to demonstrate what they know without providing an advantage over any other student;
- enable effective and appropriate engagement, interaction, and communication of student knowledge and skills;
- honor and measure academic content as the test developers originally intended;
- remove unnecessary barriers to students demonstrating the knowledge and skills being measured on ACT Aspire assessments.

The continuum of supports permitted on the ACT Aspire results in a personalized performance opportunity for all.

The unique combination of supports needed by an individual student is called the personal needs profile (PNP). A PNP tells the test delivery system which supports to provide for a specific test taker.

## 5.2.2 Universal Support Tools

Universal Support tools meet the common accessibility needs of most students. These supports are automatically available to all students without the need for a PNP. These default users are students who are able to access the test using only the basic set of accessibility features.

These accessibility features are embedded in the test delivery platform for computer-based testing or provided locally for paper-based testing.

Examples of default embedded system tools for ACT Aspire include, but are not limited to, the following:

- cut, copy, and paste functions in a text entry box (computer)
- zoom (computer)
- answer eliminator (computer and paper)
- scratch paper (computer and paper)
- personal calculators for mathematics tests (computer and paper)
- marking items for review (computer and paper)
- color overlay (paper)/color contrast (computer)
- line reader (computer and paper)
- magnifier tool (computer and paper)
- answer masking (computer and paper)

## 5.2.3 Designated Support Tools

Similar to embedded supports, open-access tools are available to all users; however, these supports must be identified, planned for, and activated (for computer-based testing) or gathered locally (for paper-based testing) before the assessment begins. These supports are slightly more intensive than Universal Support tools but can be delivered in a fully standardized manner personalized to the specific needs in a student's PNP. Many students' unique sensory and accessibility needs can be met through this a set of accessibility features.

While available to all test takers, Designated Support tools may not be needed for most students.

Examples of Designated Support tools in the ACT Aspire include, but are not limited to, the following:

- large print (paper)
- responding in test booklet or on separate paper (paper)
- dictating responses (computer and paper)
- keyboard or augmentative or assistive communication (AAC) and local print (computer and paper)
- supervised breaks each day (computer and paper)

- special seating (computer and paper)
- location for movement (computer and paper)
- group size (small group or individual administration) (computer and paper)
- location (home administration or other setting) (computer and paper)
- audio amplification (computer and paper)
- environmental changes for vision (computer and paper)
- specialized equipment (computer and paper)

## 5.2.4 Accommodations and English Learner (EL) Supports

Accommodations are intensive accessibility supports needed by relatively few students. Typically, students who receive accommodations have a documented diagnosis and their individual needs documented in a formal educational plan. This plan is developed by an educational team which includes relevant school personnel, parents/guardians, and the student. Accommodation decisions are usually based on a formal evaluation of a student and their particular needs. Any formal qualifying procedure that is required by the responsible educational authority must be completed before completing the PNP process.

Successful and secure delivery of accommodations on a standardized assessment typically requires additional local resources with specialized skills and knowledge. ACT recommends that students who use this support level have both familiarity with and expertise in the accommodation through regular use of the same supports in their educational setting.

English learner supports are appropriate for students who are not proficient in English and who receive similar supports during instruction. Unlike most disabilities, English learner status is temporary. Generally, English language proficiency is evaluated annually with assessments designed specifically to measure English proficiency. The ACT Aspire is not designed to measure English proficiency, so appropriate English learner supports can be used on this assessment.

The ACT Aspire test delivery system requires that accommodations and English learner supports be enabled by educational personnel on behalf of a student through the online PNP process. This will allow any needed resources to be assigned and documented for the student.[1]

Examples of ACT Aspire accommodations and English learner supports include, but are not limited to, the following:

- text-to-speech English audio (computer)
- text-to-speech English audio and orienting for students with blindness or low vision (computer)
- text-to-speech Spanish audio (computer)
- paper word-to-word bilingual dictionary (computer or paper)

[1] Qualifying procedures or formal documentation required to request and receive accommodation-level support during ACT Aspire testing is determined at the local level.

- human reader (paper)
- translated test directions (paper)
- Braille and tactile graphics (computer and paper)
- sign language interpretation (computer and paper)
- abacus, locally provided (computer and paper)
- extra time (computer and paper)
- breaks to securely extend session over multiple days (paper)

### 5.2.5 Support Level 4: Modifications

Modifications are supports that are sometimes used during instruction; however, they are not permitted during ACT Aspire testing. Modifications change what a student is expected to know (content) or do (performance expectations). This level of support alters what the test is attempting to measure. Because modifications violate the construct being tested, they invalidate performance results. (Modifications are further discussed in the Accessibility User Guide in the section titled “When Instruction and Assessment Supports Differ.”)

## 5.3 Accommodations, English Learners, Designated Supports, and Universal Supports

ACT Aspire provides an integrated system of accessibility supports which allow students an opportunity to access the assessment. Students may use computer-based supports, paper-based supports, or a combination of both. Regardless of test format, all students who use accessibility features must have this use documented in the online PNP by appropriate school personnel. The full list of supports permitted during the ACT Aspire summative tests, paper and online, is provided in the *ACT Aspire Accessibility Supports Guide*. Full procedural requirements and instructions for using permitted supports during test administration are also provided in the *ACT Aspire Accessibility Supports Guide*.

Table 5.1 provides the frequency of use for accommodated forms in the 2015 administration year.

**Table 5.1. Frequency of Use of Accommodated Forms, ACT Aspire, Spring 2015—continued**

| Subject/ Grade | Braille Contracted | Braille Uncontracted | English Audio for Blind | English Audio for Sighted | Large Print | Spanish | Grand Total |
|---|---|---|---|---|---|---|---|
| English | 80 | 15 | | | 455 | | 550 |
| 3 | 15 | 5 | | | 79 | | 99 |
| 4 | 11 | 3 | | | 58 | | 72 |
| 5 | 13 | 2 | | | 68 | | 83 |
| 6 | 7 | 1 | | | 50 | | 58 |
| 7 | 9 | | | | 60 | | 69 |
| 8 | 7 | 2 | | | 60 | | 69 |
| EHS | 18 | 2 | | | 80 | | 100 |
| Mathematics | 104 | 9 | 10 | 23,291 | 590 | 33 | 24,037 |
| 3 | 17 | 3 | 1 | 2,582 | 103 | 7 | 2,713 |
| 4 | 17 | 1 | | 2,692 | 83 | 9 | 2,802 |
| 5 | 17 | | | 2,814 | 94 | 13 | 2,938 |
| 6 | 16 | 1 | | 2,592 | 66 | 4 | 2,679 |
| 7 | 10 | | 1 | 2,417 | 78 | | 2,506 |
| 8 | 7 | 1 | 3 | 2,309 | 79 | | 2,399 |
| EHS | 20 | 3 | 5 | 7,885 | 87 | | 8,000 |
| Reading | 117 | 14 | | | 606 | | 737 |
| 3 | 18 | 4 | | | 110 | | 132 |
| 4 | 18 | 2 | | | 86 | | 106 |
| 5 | 19 | 1 | | | 97 | | 117 |
| 6 | 11 | 3 | | | 67 | | 81 |
| 7 | 14 | | | | 81 | | 95 |
| 8 | 14 | 3 | | | 81 | | 98 |
| EHS | 23 | 1 | | | 84 | | 108 |
| Science | 50 | 7 | 9 | 18,046 | 337 | 16 | 18,465 |
| 3 | 2 | 2 | 1 | 1,331 | 52 | | 1,388 |
| 4 | 3 | 1 | | 1,494 | 32 | 2 | 1,532 |
| 5 | 11 | 1 | | 2,656 | 56 | 12 | 2,736 |

**Table 5.1. Frequency of Use of Accommodated Forms, ACT Aspire, Spring 2015—continued**

| Subject/ Grade | Braille Contracted | Braille Uncontracted | English Audio for Blind | English Audio for Sighted | Large Print | Spanish | Grand Total |
|---|---|---|---|---|---|---|---|
| 6 | 6 | 1 | | 1,266 | 28 | 2 | 1,303 |
| 8 | 4 | 2 | 2 | 1,412 | 38 | | 1,458 |
| EHS | 19 | | 5 | 7,758 | 80 | | 7,862 |
| Writing | 70 | 23 | 7 | 13,600 | 452 | 6 | 14,158 |
| 7 | 5 | | 1 | 2,129 | 51 | | 2,186 |
| 3 | 13 | 5 | 1 | 912 | 85 | | 1,016 |
| 4 | 9 | 4 | | 1,043 | 57 | 3 | 1,116 |
| 5 | 8 | 3 | | 941 | 70 | 1 | 1,023 |
| 6 | 8 | 3 | | 1,055 | 52 | 2 | 1,120 |
| 7 | 6 | 3 | 1 | 1,039 | 57 | | 1,106 |
| 8 | 6 | 3 | 2 | 1,017 | 58 | | 1,086 |
| EHS | 20 | 2 | 3 | 7,593 | 73 | | 7,691 |
| Grand Total | 421 | 68 | 26 | 54,937 | 2,440 | 55 | 57,947 |
| % of Total | 0.73% | 0.12% | 0.04% | 94.81% | 4.21% | 0.09% | 100.00% |

Chapter 6

# Test Administration

## 6.1 Overview

The ACT Aspire test must be uniformly administered to ensure a fair and equitable testing environment for all examinees. Testing staff must strictly adhere to ACT policies and procedures during test administrations. This chapter provides a brief description of the processes used to administer ACT Aspire. Additional information about ACT Aspire, including training and test administration resources, can be found on ACT Knowledge Hub.

## 6.2 Modes

ACT Aspire Summative Assessments are administered on paper or online. ACT Aspire Periodic Assessments are administered primarily online with accessibility supports available in paper format for Interim Assessments. In addition to standard formats, ACT Aspire offers accessibility supports and English Learner (EL) supports. Additional information about accessibility and EL supports may be found in Chapter 5.

## 6.3 Policies and Procedures

### 6.3.1 Administration Manuals

For both paper and online administrations, ACT provides testing staff with a variety of documentation to support standardized administration of the test. The administration manuals provide detailed directions for selecting staff, protecting test security, and administering tests in a standardized manner. The manuals cover the following things:

- Policies and procedures to follow before, during, and after testing
- Staffing levels and responsibilities of testing staff
- Prohibited behaviors
- Handling and documenting testing irregularities
- Documentation to be submitted to ACT after testing
- Procedures for returning test materials to ACT

Every testing staff member must read the documentation before test day and adhere to these standardized procedures.

## 6.3.2 Staffing

The test coordinator is responsible for providing both the facilities and testing staff (room supervisors and other support testing staff). The test coordinator provides the continuity and administrative uniformity necessary to ensure that students at a school are tested under the same conditions as students at every other school, and to ensure the security of the test. All staff members are required to administer and supervise the ACT Aspire test in a nondiscriminatory manner and in accordance with all applicable laws, including the Americans with Disabilities Act.

## 6.3.3 Training Staff

For standardized testing to occur successfully, all staff members must understand ACT policies and procedures and their own responsibilities for implementing them. It is critical that the same procedures are followed at every testing site. The test coordinator is responsible for providing testing staff with the proper manuals and training before test day.

All staff members, both new and experienced, must attend a training session conducted by the test coordinator before the test day to discuss policy, procedural, and logistical issues and ensure that everyone understands what will take place on test day.

A staff briefing session is recommended prior to testing for all testing staff members to discuss the testing guidelines and organizational details. The test coordinator should make sure that testing staff understand their responsibilities and answer questions in a group setting so everyone has the same information at the same time.

# Chapter 7

# Test Security

## 7.1 Test Security

To ensure the validity of ACT Aspire test scores, test takers, individuals who administer the tests, and those involved in the testing process must strictly observe ACT Aspire's standardized testing policies, including the test security principles and test security requirements. Those requirements are listed in ACT Aspire's administration manuals and may be supplemented by ACT from time to time with additional communications to test takers and testing staff.

ACT Aspire's test security requirements are designed to ensure that examinees have an equal opportunity to demonstrate their academic achievement and skills, that examinees who do their own work are not unfairly disadvantaged by examinees who do not, and that scores reported for each examinee are valid. Strict observation of the test security requirements is required to safeguard the validity of the results.

Testing staff must protect the confidentiality of the test items and responses. Testing staff should be aware of and competent in their roles, including understanding ACT Aspire's test administration policies and procedures and acknowledging and avoiding conflicts of interest in their roles as test administrators.

Testing staff must be alert to activities that can compromise the fairness of the test and the validity of the scores. Such activities include, but are not limited to, cheating and questionable test-taking behavior such as copying or sharing answers; using prohibited electronic devices during testing; accessing questions before the test; taking photos or making copies of test questions or test materials; posting test questions on the internet; and testing staff or test coordinator misconduct (such as providing answers or questions to test takers or permitting test takers to engage in prohibited conduct during testing).

# 7.2 Information Security

ACT's information security program framework is based on the widely recognized ISO/IEC 27000 standard (International Organization for Standardization, 2017). This framework was selected because it covers a range of information security categories that comprehensively match the broad perspective that ACT takes in safeguarding information assets. The categories covered by the framework and brief statements of their importance to ACT are below:

1. Information Security Program Management: This is overseen by the information security officer at ACT. The information security officer has responsibility for providing guidance and direction to the organization to ensure compliance with all relevant security-related regulations and requirements. The program itself is designed to cover all security domains identified in the ISO 27001 standards and provides comprehensive oversight for information security at ACT.
2. Information Security Risk Management: The cornerstone of the ACT information security program is a risk assessment that conforms to the ISO 27005 standard. The identification, management, and mitigation of information security risks are managed using the Information Security Management System (ISMS) guidelines defined in the 27005 standard. ACT also uses the National Institute of Standards and Technology Special Publication (NIST SP) 800-37 Risk Assessment, which complies with Federal Information Security Management Act (FISMA) security requirements for risk management (National Institute of Standards and Technology, 2017).
3. Information Security Policies and Standards: ACT established an information security policy to set direction and emphasize the importance of safeguarding information and data assets. Additional supporting policies, standards, and procedures have been developed to communicate requirements.

   ACT's information security policy and the data privacy policy govern the handling of student data that is classified as confidential restricted. The policy states that confidential restricted information must meet the following guidelines:

   - Electronic information assets must only be stored on ACT-approved systems or media with appropriate access controls.
   - Only limited authorized users may access this information.
   - Physical records must be locked in drawers or cabinets while not being used.

   ACT also has the following standards: acceptable use and information asset protection, access management, business continuity, external access management, information security incident management, malware protection, mobile device, network security management, payment card security, secure application development, secure system configuration, security event logging and monitoring, system vulnerability and patch management, and web content to form a system of control to protect student data.
4. Information and Technology Compliance: The systems that store, maintain, and process information are designed to protect data security through all stages. The security considerations surrounding ACT's systems include measures such as encryption, system security requirements, and logging and monitoring to verify systems are operating within expected parameters.
5. Business Continuity and Disaster Recovery: ACT maintains a business continuity program

designed to provide assurance that critical business operations will be maintained in the event of a disruption. An essential part of the program includes a cycle of planning, testing, and updating. Disaster recovery activities are prioritized by the criticality of systems, and recovery times are established by the managers of each department.

6. Security Training and Awareness: At ACT, information security is everyone's responsibility. All employees take part in annual information security awareness training on topics covered in the information security policy. Additionally, ACT has individuals within the organization who are responsible for the management, coordination, and implementation of specific information security objectives and who receive additional information security training.
7. Identity and Access Management: ACT addresses data integrity and confidentiality by policies and procedures that 1) limit access to individuals who have a business need to know the information and 2) verify the individuals' identities. Access to ACT systems and data requires authorization from the appropriate system owner. Active Directory, file permissions, and virtual private network (VPN) remote access is administered by a security operations team who are part of ACT's IT organization.
8. Information Security Monitoring: The foundation of ACT's information security program is reflected in the information security policy, which is presented and reinforced with training to all ACT employees. ACT ensures it complies with the information security program through internal assessments of the security controls. Additionally, ACT works with independent third parties to provide assessment feedback.
9. Vulnerability and Threat Management: ACT has several mechanisms in place to identify vulnerabilities on networks, servers, and desktops. Monthly vulnerability scanning is performed by a qualified approved scanning vendor (ASV). ACT has always maintained a "compliant" status in accordance with the Payment Card Industry Data Security Standard (PCI DSS) requirements. In addition to the scans performed for PCI compliance, ACT has a suite of vulnerability scanning tools, which are coordinated with a log management and event-monitoring tool to provide reports and alerts.
10. Boundary Defense: ACT uses multiple intrusion protection and intrusion detection strategies, tools, processes, and devices to look for unusual attack mechanisms and detect a compromise of these systems. Network-based intrusion detection system (IDS) sensors are deployed on internet and extranet demilitarized zone (DMZ) systems and networks, which provide alerts for review and response. Procedures include security review, approval of changes to configurations, semiannual firewall rule review, and restrictions to deny communications with or limit data flow to known malicious IP addresses.
11. Endpoint Defenses: ACT uses a variety of tools and methods to ensure that a secure environment is maintained for the end user. These include segmentation within ACT's network, antivirus programs, and data-loss prevention programs. VPN is required for all remote access to ACT's network. Wireless access on ACT's campus requires authentication credentials, and ACT continuous scans for rogue access points.

12. Physical Security: Maintaining security on the premises where information assets reside is often considered the first line of defense in information security. ACT has implemented several security measures to ensure physical locations and equipment used to house data are protected, including card-key access to all facilities and cameras at all entry points.

13. Security Incident Response and Forensics: Planning for how to handle information security incidents is a critical component of ACT's information security program. Formal policy guidance outlines response procedures, notification protocols, and escalation procedures. Forensics are performed at the direction of the information security director.

    ACT's information security incident response plan (ISIRP) brings needed resources together in an organized manner to deal with an *incident*, classified as an adverse event related to the safety and security of ACT networks, computer systems, and data resources.

    The incident could vary: technical attacks (e.g., denial of service attack, malicious code attack, exploitation of a vulnerability), unauthorized behavior (e.g., unauthorized access to ACT systems, inappropriate usage of data, loss of physical assets containing confidential or confidential restricted data), or a combination of activities. The purpose of the plan is to outline specific steps to take in the event of any information security incident.

    The ISIRP charters an ACT information security incident response (ISIRT) team with providing an around-the-clock coordinated response to security incidents throughout ACT. Information security management has the responsibility and authority to manage the ISIRT and implement necessary actions and decisions during an incident.

# References

International Organization for Standardization. (2017). ISO/IEC 27000 family-information security management systems. Retrieved from https://www.iso.org/isoiec-27001-information-security.html.

National Institute of Standards and Technology. (2017). Computer security division computer security resource center. Retrieved from http://csrc.nist.gov/publications/PubsSPs.html.

Chapter 8

# Scores, Indicators, and Norms

## 8.1 Overview

The chapter presents the scores, indicators, and norms used for ACT Aspire reporting. The first section introduces the ACT Aspire scale scores for English, mathematics, reading, science, and the combined scores including Composite, ELA, and STEM scores as well as reporting category scores that are based on subsets of items on the subject tests. The second section addresses the ACT Readiness Benchmarks, the ACT Readiness Levels, the Progress Toward Career Readiness indicator, the Progress With Text Complexity indicator, and the ACT Readiness Ranges for reporting category scores. The third section introduces the national spring norms and fall norms for the scale scores. Note that national spring norms are used for reporting students' national percentile ranks on the score reports regardless of whether students took the tests in fall or spring. Finally, the last section shows the objective and use of ACT Aspire reports.

## 8.2 Scores

### 8.2.1 Subject Scale Scores

ACT Aspire scores are reported from grade 3 through early high school (EHS; grades 9 and 10) in English, mathematics, reading, and science. Scale scores for each subject are provided on a three-digit vertical scale, making it easier to monitor progress across grades. Table 8.1 provides the lowest obtainable scale scores (LOSS) and highest obtainable scale scores (HOSS) for each grade and subject as well as Composite score, ELA score, and STEM score (to be introduced later).

**Table 8.1. Lowest Obtainable Scale Scores (LOSS) and Highest Obtainable Scale Scores (HOSS)**

| Subject | Grade | LOSS | HOSS | Subject | Grade | LOSS | HOSS |
|---|---|---|---|---|---|---|---|
| English | 3 | 400 | 435 | Mathematics | 3 | 400 | 434 |
| | 4 | 400 | 438 | | 4 | 400 | 440 |
| | 5 | 400 | 442 | | 5 | 400 | 446 |
| | 6 | 400 | 448 | | 6 | 400 | 451 |
| | 7 | 400 | 450 | | 7 | 400 | 453 |
| | 8 | 400 | 452 | | 8 | 400 | 456 |
| | EHS | 400 | 456 | | EHS | 400 | 460 |
| Reading | 3 | 400 | 429 | Science | 3 | 400 | 433 |
| | 4 | 400 | 431 | | 4 | 400 | 436 |
| | 5 | 400 | 434 | | 5 | 400 | 438 |
| | 6 | 400 | 436 | | 6 | 400 | 440 |
| | 7 | 400 | 438 | | 7 | 400 | 443 |
| | 8 | 400 | 440 | | 8 | 400 | 446 |
| | EHS | 400 | 442 | | EHS | 400 | 449 |
| Composite Score | 3 | 400 | 433 | ELA Score | 3 | 403 | 435 |
| | 4 | 400 | 436 | | 4 | 403 | 436 |
| | 5 | 400 | 440 | | 5 | 403 | 439 |
| | 6 | 400 | 444 | | 6 | 403 | 444 |
| | 7 | 400 | 446 | | 7 | 403 | 445 |
| | 8 | 400 | 449 | | 8 | 403 | 447 |
| | EHS | 400 | 452 | | EHS | 403 | 449 |
| STEM Score | 3 | 400 | 434 | | | | |
| | 4 | 400 | 438 | | | | |
| | 5 | 400 | 442 | | | | |
| | 6 | 400 | 446 | | | | |
| | 7 | 400 | 448 | | | | |
| | 8 | 400 | 451 | | | | |
| | EHS | 400 | 455 | | | | |

## 8.2.2 Composite Score

The ACT Aspire Composite score represents overall performance on the English, mathematics, reading, and science tests.[1] It is calculated as the average of the scale scores on the four subjects rounded to an integer (.5 rounds up). Starting from fall 2019, the Composite score is reported for students from all grades if they earn valid scale scores on the four subject tests at the same grade; before that, it was only available for grade 8 and above.

Averaging four ACT Aspire subject test scale scores to obtain a Composite score implies that each test contributes equally to the Composite score. The weights used to calculate the Composite score (in this case, .25) are often referred to as *nominal weights*. Other definitions of the contribution of a test score to a Composite score may be more useful. For example, Wang and Stanley (1970) described effective weights as an index of the contribution of a test score to a Composite score. Specifically, the contribution of a test score is defined as the sum of the covariances between the test score and all components contributing to the Composite score. These contributions can be summed over tests, and then each can be divided by the sum to arrive at proportional effective weights. Proportional effective weights are referred to as *effective weights* here.

With nominal weights of .25 for each test, the effective weights can be used to verify that the nominal weight interpretation of Composite scores (i.e., Composite score as an equally weighted combination of contributing scores) is reasonable. Wang and Stanley (1970) stated that variables would rarely have equal effective weights unless explicitly designed to do so. Therefore, the effective weights would need to deviate substantially and consistently from nominal weights to justify applying different weights or a different interpretation of weights.

Table 8.2 shows the effective weights for the ACT Aspire Composite scores based on the spring 2013 data used for establishing the ACT Aspire scales. The weights ranged from .14 to .32. The mathematics tests at grades 3–6 appeared to have smaller effective weights compared to English, reading, and science due to relatively smaller variances and covariances from mathematics scores. However, the equal nominal weights appeared justifiable for ACT Aspire Composite scores.

**Table 8.2. Effective Weights for Composite Scores**

| Grade | English | Mathematics | Reading | Science |
|---|---|---|---|---|
| 3 | .29 | .16 | .25 | .29 |
| 4 | .28 | .14 | .27 | .31 |
| 5 | .29 | .15 | .26 | .29 |
| 6 | .29 | .18 | .25 | .28 |
| 7 | .29 | .21 | .23 | .27 |
| 8 | .29 | .23 | .23 | .26 |
| 9 | .32 | .23 | .22 | .24 |
| 10 | .31 | .24 | .22 | .24 |

*Note*. Percentages within a grade may not add up to 1 due to rounding.

[1] Note that the writing test is not included in the Composite score.

## 8.2.3 ELA Score

The ACT Aspire ELA score represents overall performance on the English, reading, and writing tests. It is the average of the scale scores on the three subjects rounded to an integer (.5 rounds up). Note that the writing scale score is not used for reporting but is used for the calculation of ELA scores. ELA scores are provided to students at all grades but only when a student obtains scale scores for all three subject tests at the same grade. Nominal weights for ELA scores are .33 (equal weights for each of the three contributing subject scores). The effective weights based on spring 2013 data are listed in Table 8.3 and ranged from .26 to .43. English appeared to contribute more to the effective weights for grades 7–10, with weights greater than .40, compared to writing, where weights dipped below .30. However, the effective weights did not deviate far from the equal nominal weights for ELA scores.

**Table 8.3. Effective Weights for ELA Scores**

| Grade | English | Reading | Writing |
|---|---|---|---|
| 3 | .35 | .30 | .35 |
| 4 | .33 | .31 | .36 |
| 5 | .36 | .32 | .33 |
| 6 | .36 | .30 | .33 |
| 7 | .41 | .31 | .29 |
| 8 | .42 | .32 | .26 |
| 9 | .43 | .30 | .27 |
| 10 | .43 | .30 | .27 |

*Note*. Percentages within a grade may not add up to 1 due to rounding.

## 8.2.4 STEM Score

The ACT Aspire STEM score represents overall performance on the mathematics and science tests. It is the average of the scale scores on the two subjects rounded to an integer (.5 rounds up). The STEM score is provided for students at all grades but only when a student obtains scale scores for mathematics and science tests at the same grade. Nominal weights for STEM are .5 (equal weights for each of the two contributing subject scores). The effective weights based on spring 2013 data are listed in Table 8.4 and ranged from .33 to .67. Similar to what was observed for Composite score effective weights, the mathematics scores had smaller variances and covariances compared to science, particularly for grades 3, 4, and 5, which resulted in smaller effective weights. Despite the observed differences at lower grades, where science contributed nearly double to the STEM score variance compared to mathematics, the effective weights for grades 6–10 were progressively more similar to the nominal weights.

**Table 8.4. Effective Weights for STEM Scores**

| Grade | Mathematics | Science |
|---|---|---|
| 3 | .36 | .64 |
| 4 | .33 | .67 |
| 5 | .37 | .63 |
| 6 | .42 | .58 |
| 7 | .45 | .55 |
| 8 | .48 | .52 |
| 9 | .50 | .50 |
| 10 | .50 | .50 |

## 8.2.5 Reporting Category Scores

Student performance is also described in terms of the ACT Aspire reporting category scores. Score reports describe the percent and number of points students earn out of the total number of points possible in each reporting category. A list of the reporting categories for English, mathematics, reading, and science can be found in Table 8.5. Reporting category scores can be used as supplemental information to further identify a student's strength and weakness in areas within a subject.

**Table 8.5. Reporting Categories Within Each Subject**

| Subject | Reporting Category |
|---|---|
| English | Production of Writing |
| | Knowledge of Language |
| | Conventions of Standard English |
| Mathematics | Grade Level Progress |
| | Number and Operations—Fractions |
| | Number and Operations in Base 10 |
| | The Number System |
| | Number and Quantity |
| | Operations and Algebraic Thinking |
| | Expressions and Equations |
| | Ratios and Proportional Relationships |
| | Algebra |
| | Functions |
| | Geometry |
| | Measurement and Data |
| | Statistics and Probability |
| | Integrating Essential Skills |
| | Justification and Explanation |
| | Modeling |
| Reading | Key Ideas and Details |
| | Craft and Structure |
| | Integration of Knowledge and Ideas |
| Science | Interpretation of Data |
| | Scientific Investigation |
| | Evaluation of Models, Inferences, and Experimental Results |

## 8.2.6 Writing Domain Scores

Writing scores are reported on four domains: Ideas and Analysis, Development and Support, Organization, and Language Use and Conventions. These domains measure essential skills and abilities that are required for college and career success. The domain scores are based on an analytic scoring rubric. For each domain, the essay is rated on a scale of 1 to 5 for grades 3–5 and 1 to 6 for grades 6–EHS. Writing scale score is not in the report but solely used for the calculation of the ELA score, because the ELA score is intended to be a more reliable measure of student ability than the ACT writing test score, which is based on a student's response to a single prompt.

# 8.3 Indicators

## 8.3.1 ACT Readiness Benchmarks and Readiness Levels

The ACT Readiness Benchmarks used with ACT Aspire were created to be aligned with the ACT College Readiness Benchmarks. Each ACT Aspire grade and subject test has its own ACT Readiness Benchmark. Students at or above the benchmark are on target to meet the corresponding ACT College Readiness Benchmarks in grade 11. ACT Readiness Benchmarks are available on the four subject tests in English, mathematics, reading, and science as well as on ELA and STEM scores. In addition to the ACT Readiness Benchmarks, students are provided with a description of how they perform relative to the ACT Readiness Benchmarks in English, mathematics, reading, and science. This description is called the ACT Readiness Level, which includes four categories defined by three cut scores: Exceeding, Ready, Close, and In Need of Support. Like the ACT Readiness Benchmarks, the ACT Readiness Levels are also subject and grade specific. Refer to Chapter 9 for details in the development of the ACT Readiness Benchmarks and Readiness Levels.

## 8.3.2 Progress Toward Career Readiness Indicator

The Progress Toward Career Readiness indicator is available for students at grade 8 through EHS and represents a prediction of achievement on the ACT WorkKeys National Career Readiness Certificate® toward the end of high school (see Chapter 9 for details on how the indicator was developed). The indicator is a verbal statement indicating which certificate level (i.e., Bronze, Silver, Gold, or Platinum) students are expected to achieve by the end of high school based on their ACT Aspire Composite score. One purpose of the indicator is to encourage students to think about the knowledge and skills future job training will require. Whether or not a student plans to enter college immediately after high school, there is likely a need for some postsecondary training.

## 8.3.3 Progress With Text Complexity Indicator

The Progress With Text Complexity indicator ("Yes" or "No") indicates whether students have made sufficient progress in reading increasingly complex texts (see Chapter 3, section 3.3.2.3). This indicator is based on a subset of items from the ACT Aspire reading test that are indicative of how well students can read and understand increasingly complex texts. It is derived by comparing the percent correct on the subset of items to an empirically defined cut score, which is estimated using a regression method, as the score of students at the Benchmark for the reading test (see Chapter 9 for a description of the development of the ACT Readiness Benchmarks).

## 8.3.4 Readiness Range for Reporting Categories

The ACT Readiness Range in each reporting category is provided to show how a student who has met the ACT Readiness Benchmark in a particular subject would typically perform on a reporting category. In this way students can compare the percentage of points achieved in each category to the percentage of points attained by a typical student who is on track to be ready. If their scores fall below the ACT Readiness Range, they may need additional support. See details in Chapter 9 for the methodology in developing the ACT Readiness Ranges.

# 8.4 Norms

## 8.4.1 Spring Norms

ACT Aspire started with the goal of reporting three-year rolling user norms with equal weights to each student. Beginning with fall 2015 reporting, the norm data have been statistically weighted to more closely match a national distribution in terms of selected student demographics and achievement.

This section describes the development of ACT Aspire spring norms (used interchangeably with ACT Aspire norms hereafter) based on weighted data from tests administered through spring 2019; these spring norms were used for reporting during the 2019-2020 and the 2020–2021 academic years. First, the inclusion rules for the norm samples are described. Then, the demographic information for the weighted samples, the ACT Aspire norms tables, and summary statistics based on the weighted samples are presented. This section ends with a description of a weighting methodology designed to produce nationally representative norms. Note that this section is mainly for illustration and is not based on data used to produce the three-year rolling norms for reporting in the 2019-2020 and the 2020–2021 academic years.

At ACT, we continue to update information regarding norms annually, but the methodology is similar to what is described below. The latest norm tables will be included in the technical manual when it gets updated and will either be provided online or available from ACT upon request.

### *8.4.1.1 Sample Descriptions for Spring Norms*

For grades 3–8, the spring norm samples included students who took ACT Aspire on-grade subject tests in spring 2017, spring 2018, or spring 2019 as consistent with the goal to include the latest three years of data.

For grades 9 and 10, the spring norm samples were restricted to students who took ACT Aspire in consecutive years. As described later, these longitudinal samples were used to anchor the grade 9 and grade 10 norm samples to the grade 8 and grade 9 score distributions, respectively. The grade 9 samples included students who took the on-grade Aspire subject tests in grade 8 and grade 9 approximately one year apart, with the grade 9 tests taken during academic years 2013–2014 through 2018–2019.

Similarly, the grade 10 samples included students who took ACT Aspire in grade 9 and grade 10 approximately one year apart, with the grade 10 test taken during the same aforementioned academic years. Table 8.6 provides the sample sizes by grade and subject. As mentioned earlier, the spring test-taker samples were weighted to support interpretations of nationally representative norms. The demographics information on the weighted samples for creating spring norms are presented in Tables 8.7–8.13.

**Table 8.6. Sample Sizes Used for Spring Norm Establishment**

| | Subject | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | Composite | ELA | STEM |
| 3 | 168,922 | 207,624 | 207,409 | 175,725 | 166,774 | 157,320 | 175,597 |
| 4 | 173,182 | 211,409 | 211,130 | 180,876 | 170,943 | 164,422 | 180,723 |
| 5 | 174,127 | 211,052 | 210,778 | 209,855 | 172,144 | 165,446 | 209,289 |
| 6 | 181,830 | 217,357 | 217,123 | 188,605 | 178,487 | 169,987 | 188,232 |
| 7 | 200,426 | 232,676 | 232,441 | 230,944 | 197,163 | 186,558 | 229,625 |
| 8 | 196,559 | 228,220 | 228,216 | 199,988 | 192,289 | 180,153 | 198,965 |
| 9 | 196,462 | 197,825 | 196,520 | 187,850 | 182,602 | 154,562 | 186,360 |
| 10 | 478,318 | 480,429 | 477,901 | 466,485 | 455,161 | 421,317 | 462,771 |

### *8.4.1.2 Spring Norm Tables and Related Statistics*

The spring norm table includes the cumulative percentages of students scoring at or below each scale score in the weighted norm sample from spring testers. The empirical cumulative percentages were smoothed to reduce the sampling error and increase the precision of the norms. The spring norm tables are presented in Tables 8.14–8.20. These tables list the cumulative percentage of students who are at or below each scale score point in the weighted norm sample. For example, a cumulative percent of 50 for a scale score of 420 on the grade 7 mathematics test means that 50% of students in the grade 7 weighted norm group achieved a scale score of 420 or below.

The mean scale score values for students in each grade and subject test are given in Table 8.21. These represent estimated mean scores if all students in the target population (all U.S. elementary and secondary school students) were to take the test. For the same target population, Table 8.22 also shows the estimated percentages of students meeting the ACT Readiness Benchmarks. Note that norm-related information in these tables is used in ACT Aspire reporting for the 2019-2020 and the 2020–2021 academic years. These tables will be updated annually using the new norm sample by replacing data from the oldest administration with those from the latest administration, and the values are expected to be slightly different as a result of the updates.

**Table 8.7. Demographics of Spring Weighted Samples for Creating English Norms**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Gender** | | | | | | | | |
| F | 49.00 | 49.31 | 49.08 | 48.71 | 48.99 | 49.13 | 49.18 | 49.11 |
| M | 51.00 | 50.69 | 50.92 | 51.29 | 51.01 | 50.87 | 50.66 | 50.65 |
| No response | - | - | - | - | - | - | 0.16 | 0.24 |
| **State** | | | | | | | | |
| AK | - | - | - | <0.01 | - | - | - | - |
| AL | 18.04 | 17.85 | 17.61 | 15.53 | 14.10 | 14.62 | 1.04 | 0.36 |
| AR | 70.55 | 69.98 | 68.17 | 64.01 | 62.07 | 60.46 | 51.55 | 20.67 |
| AS | - | - | - | - | - | - | 0.01 | 0.01 |
| AZ | 0.09 | 0.07 | 0.08 | 0.08 | 0.39 | 0.09 | 0.72 | 0.37 |
| CA | 0.62 | 0.61 | 2.29 | 4.98 | 4.78 | 3.65 | 1.02 | 2.15 |
| CO | 0.31 | 0.35 | 0.39 | 0.91 | 0.79 | 0.82 | 5.82 | 1.44 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.05 |
| DC | - | - | - | 0.05 | 0.03 | 0.03 | 0.04 | 0.02 |
| FL | 0.14 | 0.14 | 0.15 | 0.32 | 0.33 | 0.35 | 0.83 | 2.42 |
| GA | 0.03 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.30 | 0.21 |
| GU | 0.16 | 0.16 | 0.15 | 0.17 | 0.18 | 0.18 | 3.91 | 1.40 |
| HI | - | - | 0.01 | 0.02 | 0.02 | 1.73 | 1.11 | 1.04 |
| IA | 0.58 | 0.58 | 0.57 | 0.63 | 0.71 | 0.72 | 0.72 | 0.23 |
| IL | 3.23 | 3.21 | 3.07 | 2.94 | 2.85 | 2.84 | 2.24 | 2.28 |
| IN | - | - | - | 0.19 | 0.34 | 0.36 | 1.64 | 0.22 |
| KS | 1.00 | 0.95 | 1.18 | 3.78 | 2.66 | 3.36 | 4.32 | 2.41 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.20 | 0.68 | 0.17 |
| LA | 3.27 | 3.26 | 3.31 | 3.23 | 2.79 | 2.69 | 4.57 | 1.51 |
| MA | - | - | - | - | - | - | - | 0.09 |
| MD | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.13 | 0.13 |
| MI | 0.07 | 0.08 | 0.08 | 0.09 | 0.18 | 0.18 | 0.72 | 0.83 |
| MN | - | - | - | 0.01 | 2.62 | 0.09 | 1.93 | 0.88 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.09 | 0.04 | 1.40 | 0.75 |

**Table 8.7. Demographics of Spring Weighted Samples for Creating English Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State—continued | | | | | | | | |
| MP | - | - | - | - | - | - | 1.32 | 0.51 |
| MS | 0.30 | 0.30 | 0.29 | 0.27 | 0.32 | 0.30 | 2.33 | 0.57 |
| MT | - | - | - | 0.02 | 0.02 | 0.31 | 0.13 | 0.13 |
| NC | 0.05 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | 0.05 | 0.10 | 0.10 | 0.02 | 0.03 | 0.06 | 0.06 | 0.62 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.28 | 0.90 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.02 | 0.06 | 0.34 |
| NM | - | - | - | - | - | - | 0.12 | 0.07 |
| NV | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.40 | 0.19 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.09 | 0.24 |
| OH | - | 0.16 | 0.19 | 0.17 | 0.21 | 0.59 | 2.72 | 1.23 |
| OK | 0.25 | 0.78 | 0.91 | 1.00 | 0.98 | 1.03 | 0.92 | 0.30 |
| OR | <0.01 | <0.01 | <0.01 | 0.05 | 0.03 | 0.03 | 0.11 | 0.32 |
| PA | 0.12 | 0.12 | 0.12 | 0.10 | 0.09 | 0.08 | 0.15 | 0.44 |
| SC | 0.03 | 0.02 | 0.03 | 0.03 | 0.04 | 0.02 | 1.10 | 0.30 |
| SD | 0.07 | 0.08 | 0.09 | 0.08 | 0.17 | 0.08 | 0.05 | 0.06 |
| TN | 0.17 | 0.17 | 0.22 | 0.29 | 0.37 | 0.48 | 1.10 | 0.49 |
| TX | 0.12 | 0.26 | 0.15 | 0.18 | 0.57 | 0.41 | 0.90 | 0.48 |
| UT | 0.25 | 0.16 | 0.23 | 0.14 | 0.20 | 0.13 | 0.18 | 0.17 |
| VA | - | - | - | - | - | 0.01 | 0.06 | 0.20 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.06 |
| WI | 0.31 | 0.32 | 0.32 | 0.32 | 1.59 | 3.77 | 3.03 | 51.32 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 | 0.01 | 0.01 | 1.26 |
| No response | - | - | - | - | - | - | 0.08 | 0.06 |

**Table 8.7. Demographics of Spring Weighted Samples for Creating English Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.79 | 24.73 | 24.67 | 24.6 | 24.57 | 24.57 | 10.56 | 12.56 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.67 | 0.73 |
| Asian | 4.63 | 4.62 | 4.62 | 4.65 | 4.64 | 4.64 | 2.81 | 3.40 |
| Black/African American | 14.27 | 14.25 | 14.22 | 14.21 | 14.19 | 14.19 | 12.67 | 9.37 |
| White | 46.34 | 46.31 | 46.33 | 46.27 | 46.21 | 46.22 | 49.2 | 61.36 |
| Other | 1.55 | 1.54 | 1.42 | 1.17 | 0.80 | 0.55 | 3.38 | 3.33 |
| Unknown | 7.51 | 7.64 | 7.81 | 8.19 | 8.67 | 8.91 | 20.71 | 9.24 |

*Note*. - indicates no students tested.

**Table 8.8. Demographics of Spring Weighted Samples for Creating Mathematics Norms**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gender | | | | | | | | |
| F | 49.08 | 49.23 | 49.12 | 48.85 | 48.9 | 49.08 | 49.27 | 48.89 |
| M | 50.92 | 50.77 | 50.88 | 51.15 | 51.1 | 50.92 | 50.49 | 50.87 |
| No response | - | - | - | - | - | - | 0.25 | 0.24 |
| State | | | | | | | | |
| AK | - | - | - | <0.01 | - | - | - | - |
| AL | 33.81 | 33.48 | 32.32 | 30.07 | 27.33 | 27.46 | 1.16 | 0.35 |
| AR | 55.18 | 54.89 | 54.28 | 51.88 | 51.39 | 50.22 | 51.08 | 20.63 |
| AS | - | - | - | - | - | - | 0.02 | 0.01 |
| AZ | 0.09 | 0.07 | 0.08 | 0.07 | 0.39 | 0.08 | 0.64 | 0.35 |
| CA | 0.62 | 0.61 | 2.01 | 4.59 | 4.42 | 3.49 | 1.32 | 2.19 |
| CO | 0.31 | 0.36 | 0.39 | 0.68 | 0.73 | 0.76 | 5.85 | 1.44 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.05 |
| DC | - | - | - | 0.04 | 0.03 | 0.02 | 0.07 | 0.02 |
| FL | 0.14 | 0.14 | 0.16 | 0.32 | 0.34 | 0.35 | 0.85 | 2.35 |
| GA | 0.03 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.31 | 0.22 |
| GU | 0.16 | 0.16 | 0.15 | 0.17 | 0.18 | 0.18 | 2.99 | 1.19 |
| HI | - | - | <0.01 | 0.02 | 0.02 | 1.53 | 1.08 | 1.06 |
| IA | 0.43 | 0.42 | 0.43 | 0.50 | 0.57 | 0.60 | 0.70 | 0.27 |
| IL | 3.23 | 3.21 | 3.06 | 2.94 | 2.85 | 2.84 | 2.37 | 2.26 |
| IN | - | - | - | 0.19 | 0.31 | 0.33 | 1.56 | 0.22 |
| KS | 0.92 | 0.88 | 1.10 | 2.53 | 2.17 | 2.80 | 4.26 | 2.46 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.20 | 0.67 | 0.17 |
| LA | 3.21 | 3.2 | 3.25 | 3.05 | 2.60 | 2.45 | 4.54 | 1.45 |
| MA | - | - | - | - | - | - | - | 0.09 |
| MD | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.13 | 0.14 |
| MI | 0.07 | 0.08 | 0.08 | 0.09 | 0.18 | 0.18 | 0.73 | 0.82 |
| MN | - | - | - | 0.01 | 1.73 | 0.09 | 1.95 | 0.87 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.08 | 0.04 | 1.39 | 0.74 |

Table 8.8. Demographics of Spring Weighted Samples for Creating Mathematics Norms—continued

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| MP | - | - | - | - | - | - | 1.28 | 0.53 |
| MS | 0.31 | 0.30 | 0.29 | 0.27 | 0.31 | 0.29 | 2.29 | 0.58 |
| MT | - | - | - | 0.01 | 0.02 | 0.34 | 0.13 | 0.13 |
| NC | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | 0.02 | 0.05 | 0.04 | 0.01 | 0.02 | 0.06 | 0.05 | 0.61 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.38 | 0.89 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.02 | 0.07 | 0.35 |
| NM | - | - | - | - | - | - | 0.13 | 0.10 |
| NV | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.08 | 0.65 | 0.50 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.09 | 0.25 |
| OH | - | 0.12 | 0.14 | 0.14 | 0.38 | 0.63 | 3.02 | 1.34 |
| OK | 0.20 | 0.69 | 0.82 | 0.90 | 0.91 | 0.96 | 0.94 | 0.28 |
| OR | <0.01 | <0.01 | <0.01 | 0.02 | 0.03 | 0.03 | 0.11 | 0.35 |
| PA | 0.12 | 0.12 | 0.12 | 0.10 | 0.09 | 0.08 | 0.15 | 0.46 |
| SC | 0.03 | 0.02 | 0.03 | 0.03 | 0.04 | 0.02 | 1.10 | 0.30 |
| SD | 0.07 | 0.08 | 0.09 | 0.08 | 0.17 | 0.08 | 0.05 | 0.06 |
| TN | 0.17 | 0.17 | 0.22 | 0.29 | 0.36 | 0.47 | 1.09 | 0.47 |
| TX | 0.13 | 0.23 | 0.15 | 0.18 | 0.51 | 0.36 | 0.95 | 0.46 |
| UT | 0.25 | 0.16 | 0.23 | 0.14 | 0.20 | 0.13 | 0.19 | 0.17 |
| VA | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 | 0.07 | 0.19 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.05 |
| WI | 0.28 | 0.30 | 0.29 | 0.30 | 1.18 | 2.59 | 3.39 | 51.20 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 1.26 |
| No response | - | - | - | - | - | - | 0.08 | 0.06 |

**Table 8.8. Demographics of Spring Weighted Samples for Creating Mathematics Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.79 | 24.73 | 24.67 | 24.60 | 24.57 | 24.57 | 10.59 | 12.87 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.66 | 0.75 |
| Asian | 4.63 | 4.63 | 4.62 | 4.65 | 4.64 | 4.64 | 2.93 | 3.41 |
| Black/African American | 14.27 | 14.25 | 14.23 | 14.21 | 14.19 | 14.19 | 12.26 | 9.73 |
| White | 46.32 | 46.29 | 46.32 | 46.26 | 46.21 | 46.22 | 49.9 | 60.68 |
| Other | 1.27 | 1.29 | 1.19 | 0.98 | 0.75 | 0.53 | 3.34 | 3.37 |
| Unknown | 7.81 | 7.89 | 8.05 | 8.39 | 8.72 | 8.93 | 20.32 | 9.19 |

*Note.* - indicates no students tested.

**Table 8.9. Demographics of Spring Weighted Samples for Creating Reading Norms**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gender | | | | | | | | |
| F | 49.09 | 49.24 | 49.12 | 48.83 | 48.9 | 49.06 | 49.47 | 48.94 |
| M | 50.91 | 50.76 | 50.88 | 51.17 | 51.1 | 50.94 | 50.29 | 50.82 |
| No response | - | - | - | - | - | - | 0.24 | 0.24 |
| State | | | | | | | | |
| AK | - | - | - | - | - | - | - | - |
| AL | 33.72 | 33.41 | 32.23 | 29.99 | 27.24 | 27.37 | 1.17 | 0.35 |
| AR | 55.27 | 54.96 | 54.36 | 51.93 | 51.45 | 50.21 | 51.35 | 20.65 |
| AS | - | - | - | - | - | - | 0.01 | 0.01 |
| AZ | 0.09 | 0.07 | 0.08 | 0.08 | 0.39 | 0.08 | 0.64 | 0.35 |
| CA | 0.62 | 0.61 | 2.03 | 4.61 | 4.42 | 3.50 | 1.35 | 2.20 |
| CO | 0.31 | 0.34 | 0.39 | 0.68 | 0.73 | 0.75 | 5.76 | 1.40 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.04 |
| DC | - | - | - | 0.04 | 0.03 | 0.02 | 0.04 | 0.02 |
| FL | 0.14 | 0.14 | 0.16 | 0.32 | 0.34 | 0.35 | 0.85 | 2.35 |
| GA | 0.03 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.31 | 0.21 |
| GU | 0.16 | 0.16 | 0.15 | 0.17 | 0.18 | 0.18 | 3.02 | 1.16 |
| HI | - | - | <0.01 | 0.02 | 0.02 | 1.54 | 1.08 | 1.06 |
| IA | 0.43 | 0.42 | 0.43 | 0.50 | 0.57 | 0.60 | 0.71 | 0.26 |
| IL | 3.23 | 3.21 | 3.06 | 2.94 | 2.85 | 2.84 | 2.36 | 2.27 |
| IN | - | - | - | 0.19 | 0.31 | 0.33 | 1.5 | 0.23 |
| KS | 0.92 | 0.88 | 1.10 | 2.53 | 2.16 | 2.80 | 4.25 | 2.43 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.20 | 0.64 | 0.17 |
| LA | 3.21 | 3.21 | 3.25 | 3.06 | 2.60 | 2.46 | 4.58 | 1.48 |
| MA | - | - | - | - | - | - | - | 0.08 |
| MD | 0.01 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.14 | 0.14 |
| MI | 0.07 | 0.08 | 0.08 | 0.09 | 0.18 | 0.18 | 0.73 | 0.82 |
| MN | - | - | - | 0.01 | 1.74 | 0.09 | 1.94 | 0.87 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.09 | 0.04 | 1.41 | 0.74 |

**Table 8.9. Demographics of Spring Weighted Samples for Creating Reading Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State — continued | | | | | | | | |
| MP | - | - | - | - | - | - | 1.31 | 0.52 |
| MS | 0.31 | 0.31 | 0.29 | 0.27 | 0.31 | 0.29 | 2.31 | 0.58 |
| MT | - | - | - | 0.01 | 0.02 | 0.33 | 0.13 | 0.13 |
| NC | 0.04 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | 0.03 | 0.05 | 0.04 | 0.01 | 0.02 | 0.05 | 0.05 | 0.63 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.38 | 0.91 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.02 | 0.05 | 0.32 |
| NM | - | - | - | - | - | - | 0.12 | 0.13 |
| NV | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.65 | 0.49 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.09 | 0.11 |
| OH | - | 0.12 | 0.14 | 0.13 | 0.40 | 0.72 | 3.09 | 1.36 |
| OK | 0.2 | 0.68 | 0.82 | 0.91 | 0.91 | 0.92 | 0.94 | 0.29 |
| OR | <0.01 | <0.01 | <0.01 | 0.02 | 0.03 | 0.03 | 0.11 | 0.35 |
| PA | 0.12 | 0.12 | 0.12 | 0.10 | 0.09 | 0.08 | 0.15 | 0.45 |
| SC | 0.03 | 0.02 | 0.03 | 0.03 | 0.04 | 0.02 | 1.04 | 0.30 |
| SD | 0.07 | 0.08 | 0.09 | 0.08 | 0.17 | 0.08 | 0.05 | 0.05 |
| TN | 0.17 | 0.17 | 0.22 | 0.29 | 0.36 | 0.47 | 1.11 | 0.48 |
| TX | 0.13 | 0.24 | 0.15 | 0.18 | 0.52 | 0.40 | 0.76 | 0.40 |
| UT | 0.25 | 0.16 | 0.23 | 0.14 | 0.20 | 0.13 | 0.19 | 0.17 |
| VA | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 | 0.07 | 0.12 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.05 |
| WI | 0.28 | 0.30 | 0.29 | 0.30 | 1.18 | 2.60 | 3.35 | 51.44 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 1.26 |
| No response | - | - | - | - | - | - | 0.07 | 0.06 |

**Table 8.9. Demographics of Spring Weighted Samples for Creating Reading Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.8 | 24.73 | 24.67 | 24.6 | 24.57 | 24.57 | 10.66 | 12.71 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.66 | 0.74 |
| Asian | 4.63 | 4.63 | 4.62 | 4.65 | 4.64 | 4.64 | 2.87 | 3.41 |
| Black/African American | 14.27 | 14.25 | 14.23 | 14.21 | 14.19 | 14.19 | 12.47 | 9.48 |
| White | 46.32 | 46.29 | 46.32 | 46.27 | 46.21 | 46.22 | 49.75 | 61.3 |
| Other | 1.27 | 1.30 | 1.21 | 0.99 | 0.75 | 0.53 | 3.36 | 3.35 |
| Unknown | 7.80 | 7.89 | 8.03 | 8.38 | 8.72 | 8.93 | 20.22 | 9.00 |

*Note.* - indicates no students tested.

**Table 8.10. Demographics of Spring Weighted Samples for Creating Science Norms**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Gender** | | | | | | | | |
| F | 49.07 | 49.30 | 49.13 | 48.85 | 48.91 | 49.12 | 49.16 | 48.87 |
| M | 50.93 | 50.70 | 50.87 | 51.15 | 51.09 | 50.88 | 50.57 | 50.89 |
| No response | - | - | - | - | - | - | 0.27 | 0.24 |
| **State** | | | | | | | | |
| AK | - | - | - | <0.01 | - | - | - | - |
| AL | 21.54 | 21.81 | 32.42 | 19.08 | 27.44 | 17.25 | 1.11 | 0.36 |
| AR | 67.27 | 66.29 | 54.25 | 61.56 | 51.36 | 58.47 | 53.64 | 21.21 |
| AS | - | - | - | - | - | - | 0.01 | 0.01 |
| AZ | 0.09 | 0.08 | 0.08 | 0.08 | 0.39 | 0.09 | 0.67 | 0.35 |
| CA | 0.62 | 0.62 | 2.00 | 4.95 | 4.43 | 3.66 | 1.31 | 1.83 |
| CO | 0.31 | 0.37 | 0.40 | 0.50 | 0.64 | 0.68 | 6.06 | 1.44 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.02 |
| DC | - | - | - | 0.02 | 0.01 | 0.03 | 0.05 | 0.02 |
| FL | 0.14 | 0.14 | 0.16 | 0.32 | 0.34 | 0.36 | 0.75 | 2.35 |
| GA | 0.04 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.32 | 0.21 |
| GU | - | - | - | - | - | - | - | - |
| HI | - | - | - | 0.02 | 0.02 | 1.69 | 1.15 | 1.07 |
| IA | 0.52 | 0.53 | 0.43 | 0.60 | 0.58 | 0.70 | 0.76 | 0.27 |
| IL | 3.32 | 3.29 | 3.14 | 3.03 | 2.93 | 2.91 | 2.47 | 2.31 |
| IN | - | - | - | 0.19 | 0.32 | 0.36 | 1.62 | 0.23 |
| KS | 0.99 | 0.94 | 1.08 | 3.42 | 2.17 | 3.20 | 4.40 | 2.46 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.21 | 0.72 | 0.17 |
| LA | 3.32 | 3.30 | 3.32 | 3.20 | 2.66 | 2.61 | 4.75 | 1.50 |
| MA | - | - | - | - | - | - | - | 0.09 |
| MD | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.09 |
| MI | 0.05 | 0.06 | 0.06 | 0.09 | 0.19 | 0.18 | 0.72 | 0.81 |
| MN | - | - | - | 0.01 | 1.76 | 0.10 | 2.03 | 0.90 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.08 | 0.04 | 1.47 | 0.74 |

**Table 8.10. Demographics of Spring Weighted Samples for Creating Science Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State — continued | | | | | | | | |
| MS | 0.30 | 0.31 | 0.30 | 0.28 | 0.32 | 0.30 | 2.42 | 0.56 |
| MT | - | - | - | 0.01 | 0.02 | 0.36 | 0.14 | 0.12 |
| NC | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | - | - | - | 0.02 | 0.02 | 0.06 | 0.06 | 0.63 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.40 | 0.92 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.01 | 0.05 | 0.34 |
| NM | - | - | - | - | - | - | 0.13 | 0.11 |
| NV | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.30 | 0.18 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.10 | 0.24 |
| OH | - | 0.15 | 0.14 | 0.17 | 0.42 | 0.86 | 3.05 | 1.31 |
| OK | 0.20 | 0.75 | 0.84 | 0.96 | 0.92 | 1.05 | 1.00 | 0.29 |
| OR | <0.01 | <0.01 | <0.01 | 0.02 | 0.03 | 0.03 | 0.10 | 0.33 |
| PA | 0.12 | 0.12 | 0.12 | 0.10 | 0.09 | 0.09 | 0.16 | 0.44 |
| SC | 0.03 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 1.15 | 0.30 |
| SD | 0.07 | 0.08 | 0.09 | 0.08 | 0.18 | 0.08 | 0.05 | 0.06 |
| TN | 0.17 | 0.17 | 0.22 | 0.30 | 0.37 | 0.49 | 1.14 | 0.49 |
| TX | 0.13 | 0.27 | 0.15 | 0.19 | 0.50 | 0.41 | 0.86 | 0.40 |
| UT | 0.25 | 0.16 | 0.24 | 0.15 | 0.21 | 0.13 | 0.19 | 0.17 |
| VA | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 | 0.05 | 0.15 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.05 |
| WI | 0.28 | 0.30 | 0.29 | 0.31 | 1.15 | 3.31 | 3.07 | 52.54 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 1.27 |
| No response | - | - | - | - | - | - | 0.08 | 0.07 |

**Table 8.10. Demographics of Spring Weighted Samples for Creating Science Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.82 | 24.75 | 24.7 | 24.62 | 24.59 | 24.58 | 11.04 | 12.65 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.70 | 0.75 |
| Asian | 4.63 | 4.63 | 4.63 | 4.65 | 4.64 | 4.64 | 2.91 | 3.44 |
| Black/African American | 14.28 | 14.26 | 14.24 | 14.22 | 14.20 | 14.20 | 13.05 | 9.63 |
| White | 46.38 | 46.34 | 46.38 | 46.33 | 46.28 | 46.28 | 51.31 | 62.46 |
| Other | 1.42 | 1.42 | 1.21 | 1.08 | 0.76 | 0.56 | 3.42 | 3.36 |
| Unknown | 7.56 | 7.69 | 7.95 | 8.19 | 8.60 | 8.81 | 17.58 | 7.71 |

*Note.* - indicates no students tested.

Table 8.11. Demographics of Spring Weighted Samples for Creating Composite Score Norms

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gender | | | | | | | | |
| F | 48.98 | 49.32 | 49.12 | 48.71 | 49.01 | 49.10 | 49.16 | 48.71 |
| M | 51.02 | 50.68 | 50.88 | 51.29 | 50.99 | 50.90 | 50.68 | 51.05 |
| No response | - | - | - | - | - | - | 0.16 | 0.24 |
| State | | | | | | | | |
| AK | - | - | - | - | - | - | - | - |
| AL | 17.83 | 17.55 | 17.68 | 15.16 | 14.13 | 14.36 | 1.09 | 0.35 |
| AR | 70.86 | 70.44 | 68.36 | 64.77 | 62.30 | 61.18 | 55.12 | 21.70 |
| AS | - | - | - | - | - | - | 0.02 | 0.01 |
| AZ | 0.08 | 0.07 | 0.08 | 0.08 | 0.39 | 0.08 | 0.68 | 0.35 |
| CA | 0.62 | 0.62 | 2.26 | 5.06 | 4.77 | 3.68 | 1.08 | 1.81 |
| CO | 0.31 | 0.35 | 0.40 | 0.49 | 0.64 | 0.68 | 6.06 | 1.34 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 |
| DC | - | - | - | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 |
| FL | 0.14 | 0.15 | 0.16 | 0.33 | 0.34 | 0.36 | 0.75 | 2.36 |
| GA | 0.04 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.31 | 0.20 |
| GU | - | - | - | - | - | - | - | - |
| HI | - | - | - | 0.02 | 0.02 | 1.71 | 1.13 | 1.01 |
| IA | 0.58 | 0.57 | 0.57 | 0.64 | 0.71 | 0.73 | 0.76 | 0.23 |
| IL | 3.33 | 3.31 | 3.16 | 3.04 | 2.94 | 2.93 | 2.34 | 2.29 |
| IN | - | - | - | 0.19 | 0.32 | 0.35 | 1.42 | 0.20 |
| KS | 0.99 | 0.94 | 1.15 | 3.87 | 2.63 | 3.35 | 4.34 | 2.34 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.21 | 0.65 | 0.18 |
| LA | 3.33 | 3.31 | 3.36 | 3.25 | 2.83 | 2.66 | 4.71 | 1.46 |
| MA | - | - | - | - | - | - | - | 0.08 |
| MD | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.09 |
| MI | 0.05 | 0.06 | 0.06 | 0.09 | 0.19 | 0.18 | 0.73 | 0.81 |
| MN | - | - | - | 0.01 | 2.66 | 0.10 | 1.99 | 0.87 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.09 | 0.04 | 1.48 | 0.74 |

**Table 8.11. Demographics of Spring Weighted Samples for Creating Composite Score Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State — continued | | | | | | | | |
| MP | - | - | - | - | - | - | 1.33 | 0.47 |
| MS | 0.30 | 0.31 | 0.30 | 0.28 | 0.33 | 0.30 | 2.42 | 0.55 |
| MT | - | - | - | 0.02 | 0.02 | 0.30 | 0.14 | 0.12 |
| NC | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | - | - | - | 0.02 | 0.03 | 0.06 | 0.06 | 0.62 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.30 | 0.92 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.02 | 0.04 | 0.30 |
| NM | - | - | - | - | - | - | 0.13 | 0.03 |
| NV | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.07 | 0.30 | 0.18 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.09 | 0.11 |
| OH | - | 0.16 | 0.18 | 0.17 | 0.18 | 0.44 | 2.71 | 1.23 |
| OK | 0.24 | 0.77 | 0.87 | 0.94 | 0.94 | 0.95 | 0.92 | 0.27 |
| OR | <0.01 | <0.01 | <0.01 | 0.05 | 0.03 | 0.03 | 0.10 | 0.30 |
| PA | 0.12 | 0.12 | 0.12 | 0.10 | 0.09 | 0.09 | 0.16 | 0.42 |
| SC | 0.03 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 1.10 | 0.30 |
| SD | 0.08 | 0.09 | 0.09 | 0.08 | 0.18 | 0.08 | 0.05 | 0.05 |
| TN | 0.17 | 0.17 | 0.22 | 0.29 | 0.38 | 0.49 | 1.12 | 0.48 |
| TX | 0.12 | 0.25 | 0.15 | 0.18 | 0.58 | 0.37 | 0.81 | 0.39 |
| UT | 0.25 | 0.16 | 0.24 | 0.14 | 0.20 | 0.13 | 0.19 | 0.16 |
| VA | - | - | - | - | - | 0.01 | 0.04 | 0.11 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.05 |
| WI | 0.29 | 0.31 | 0.30 | 0.33 | 1.61 | 3.81 | 3.09 | 53.04 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 | 0.01 | <0.01 | 1.28 |
| No response | - | - | - | - | - | - | 0.07 | 0.06 |

**Table 8.11. Demographics of Spring Weighted Samples for Creating Composite Score Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.82 | 24.76 | 24.70 | 24.62 | 24.59 | 24.59 | 10.94 | 12.60 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.69 | 0.75 |
| Asian | 4.63 | 4.63 | 4.63 | 4.65 | 4.64 | 4.64 | 2.93 | 3.45 |
| Black/African American | 14.28 | 14.26 | 14.23 | 14.22 | 14.20 | 14.20 | 13.31 | 9.61 |
| White | 46.38 | 46.35 | 46.38 | 46.33 | 46.28 | 46.29 | 51.55 | 62.96 |
| Other | 1.59 | 1.57 | 1.45 | 1.19 | 0.83 | 0.57 | 3.41 | 3.33 |
| Unknown | 7.39 | 7.53 | 7.70 | 8.06 | 8.54 | 8.79 | 17.17 | 7.31 |

*Note*. - indicates no students tested.

Table 8.12. Demographics of Spring Weighted Samples for Creating ELA Score Norms

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gender | | | | | | | | |
| F | 49.67 | 49.73 | 49.24 | 49.21 | 49.13 | 49.30 | 49.88 | 49.83 |
| M | 50.33 | 50.27 | 50.76 | 50.79 | 50.87 | 50.70 | 49.98 | 50.06 |
| No response | - | - | - | - | - | - | 0.14 | 0.11 |
| State | | | | | | | | |
| AK | - | - | - | - | - | - | - | - |
| AL | 13.86 | 13.73 | 13.71 | 13.16 | 11.18 | 11.62 | 1.08 | 0.36 |
| AR | 75.36 | 75.00 | 72.80 | 68.67 | 64.21 | 63.66 | 64.55 | 23.09 |
| AS | - | - | - | - | - | - | 0.02 | 0.01 |
| AZ | 0.08 | 0.07 | 0.08 | 0.08 | 0.43 | 0.09 | 0.77 | 0.33 |
| CA | 0.63 | 0.62 | 2.27 | 5.08 | 4.93 | 3.74 | 1.21 | 2.14 |
| CO | 0.31 | 0.34 | 0.39 | 2.06 | 0.90 | 0.95 | 0.61 | 0.65 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | - |
| DC | - | - | - | 0.04 | 0.03 | 0.03 | 0.04 | 0.02 |
| FL | 0.14 | 0.15 | 0.16 | 0.34 | 0.37 | 0.39 | 0.91 | 2.56 |
| GA | 0.04 | 0.04 | 0.04 | 0.07 | 0.07 | 0.08 | 0.34 | 0.21 |
| GU | - | - | - | - | - | - | - | - |
| HI | - | - | 0.01 | 0.03 | 0.03 | 0.86 | 0.39 | 0.54 |
| IA | 0.01 | 0.01 | 0.01 | 0.06 | 0.08 | 0.15 | 0.09 | 0.05 |
| IL | 3.42 | 3.39 | 3.25 | 3.16 | 3.13 | 3.16 | 2.23 | 1.76 |
| IN | - | - | - | 0.21 | 0.34 | 0.37 | 1.70 | 0.23 |
| KS | 0.96 | 0.91 | 1.13 | 1.27 | 1.37 | 1.81 | 2.70 | 1.45 |
| KY | 0.05 | 0.05 | 0.06 | 0.09 | 0.20 | 0.23 | 0.81 | 0.15 |
| LA | 3.32 | 3.39 | 3.39 | 3.07 | 2.47 | 2.19 | 3.96 | 1.11 |
| MA | - | - | - | - | - | - | - | 0.08 |
| MD | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.10 |
| MI | 0.08 | 0.08 | 0.08 | 0.07 | 0.18 | 0.18 | 0.81 | 0.78 |
| MN | - | - | - | - | 4.60 | 0.10 | 1.88 | 0.82 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.10 | 0.05 | 1.56 | 0.52 |

**Table 8.12. Demographics of Spring Weighted Samples for Creating ELA Score Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State — continued | | | | | | | | |
| MS | 0.27 | 0.26 | 0.25 | 0.23 | 0.24 | 0.21 | 1.07 | 0.27 |
| MT | - | - | - | 0.02 | 0.02 | 0.03 | 0.16 | 0.14 |
| NC | 0.05 | 0.04 | 0.04 | 0.05 | 0.04 | 0.04 | 0.06 | 0.07 |
| ND | 0.06 | 0.13 | 0.18 | 0.08 | 0.03 | 0.08 | 0.06 | 0.45 |
| NE | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.04 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | - | - | 0.04 | 0.14 |
| NM | - | - | - | - | - | - | 0.13 | 0.03 |
| NV | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.30 | 0.16 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.10 | 0.12 |
| OH | - | 0.17 | 0.20 | 0.17 | 0.23 | 0.60 | 2.92 | 0.91 |
| OK | 0.20 | 0.41 | 0.72 | 0.74 | 0.92 | 0.93 | 0.58 | 0.28 |
| OR | <0.01 | <0.01 | <0.01 | 0.05 | 0.03 | 0.03 | 0.14 | 0.33 |
| PA | 0.13 | 0.12 | 0.12 | 0.10 | 0.10 | 0.09 | 0.19 | 0.34 |
| SC | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 1.27 | 0.31 |
| SD | 0.08 | 0.09 | 0.09 | 0.08 | 0.19 | 0.08 | 0.04 | 0.04 |
| TN | 0.10 | 0.10 | 0.14 | 0.20 | 0.23 | 0.33 | 1.07 | 0.40 |
| TX | 0.12 | 0.24 | 0.13 | 0.17 | 0.39 | 0.41 | 0.89 | 0.42 |
| UT | 0.26 | 0.16 | 0.25 | 0.15 | 0.21 | 0.14 | 0.15 | 0.09 |
| VA | - | - | - | - | - | 0.01 | 0.06 | 0.05 |
| VI | - | - | - | - | - | - | 0.07 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.06 |
| WI | 0.31 | 0.32 | 0.32 | 0.33 | 2.60 | 7.24 | 3.36 | 56.42 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.02 | 0.02 | 0.03 | 0.03 | 0.01 | 0.01 | 0.01 | 1.39 |
| No response | - | - | - | - | - | - | 0.06 | - |

**Table 8.12. Demographics of Spring Weighted Samples for Creating ELA Score Norms—continued**

| Race/Ethnicity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Hispanic/ Latino | 24.83 | 24.77 | 24.72 | 24.64 | 24.63 | 24.63 | 11.61 | 12.69 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.65 | 0.74 |
| Asian | 4.63 | 4.63 | 4.63 | 4.66 | 4.65 | 4.65 | 2.81 | 3.31 |
| Black/African American | 14.27 | 14.25 | 14.23 | 14.22 | 14.21 | 14.22 | 14.61 | 9.36 |
| White | 46.41 | 46.38 | 46.37 | 46.38 | 46.31 | 46.35 | 54.73 | 64.33 |
| Other | 1.62 | 1.63 | 1.52 | 1.32 | 0.90 | 0.71 | 3.39 | 3.18 |
| Unknown | 7.31 | 7.42 | 7.62 | 7.87 | 8.38 | 8.53 | 12.2 | 6.39 |

*Note*. - indicates no students tested.

**Table 8.13. Demographics of Spring Weighted Samples for Creating STEM Score Norms**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Gender | | | | | | | | |
| F | 49.07 | 49.29 | 49.13 | 48.86 | 48.91 | 49.12 | 49.16 | 48.81 |
| M | 50.93 | 50.71 | 50.87 | 51.14 | 51.09 | 50.87 | 50.58 | 50.95 |
| No response | - | - | - | - | - | - | 0.27 | 0.24 |
| State | | | | | | | | |
| AK | - | - | - | <0.01 | - | - | - | - |
| AL | 21.53 | 21.80 | 32.33 | 19.06 | 27.33 | 17.28 | 1.10 | 0.35 |
| AR | 67.29 | 66.31 | 54.38 | 61.63 | 51.53 | 58.67 | 54.05 | 21.41 |
| AS | - | - | - | - | - | - | 0.01 | 0.01 |
| AZ | 0.09 | 0.07 | 0.08 | 0.08 | 0.39 | 0.08 | 0.67 | 0.35 |
| CA | 0.62 | 0.62 | 1.99 | 4.95 | 4.43 | 3.65 | 1.29 | 1.82 |
| CO | 0.31 | 0.36 | 0.40 | 0.49 | 0.64 | 0.68 | 6.07 | 1.41 |
| CT | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 |
| DC | - | - | - | 0.02 | 0.01 | 0.03 | 0.05 | 0.02 |
| FL | 0.14 | 0.14 | 0.16 | 0.33 | 0.34 | 0.36 | 0.75 | 2.34 |
| GA | 0.04 | 0.04 | 0.04 | 0.07 | 0.08 | 0.08 | 0.32 | 0.20 |
| GU | - | - | - | - | - | - | - | - |
| HI | - | - | - | 0.02 | 0.02 | 1.68 | 1.14 | 1.07 |
| IA | 0.52 | 0.53 | 0.43 | 0.60 | 0.58 | 0.70 | 0.75 | 0.27 |
| IL | 3.32 | 3.30 | 3.15 | 3.04 | 2.94 | 2.92 | 2.46 | 2.31 |
| IN | - | - | - | 0.19 | 0.32 | 0.35 | 1.55 | 0.21 |
| KS | 0.98 | 0.93 | 1.08 | 3.40 | 2.16 | 3.18 | 4.36 | 2.44 |
| KY | 0.05 | 0.04 | 0.05 | 0.08 | 0.18 | 0.21 | 0.71 | 0.18 |
| LA | 3.32 | 3.30 | 3.32 | 3.19 | 2.65 | 2.60 | 4.69 | 1.47 |
| MA | - | - | - | - | - | - | - | 0.09 |
| MD | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.10 |
| MI | 0.05 | 0.06 | 0.06 | 0.09 | 0.19 | 0.18 | 0.72 | 0.81 |
| MN | - | - | - | 0.01 | 1.75 | 0.10 | 2.03 | 0.89 |
| MO | 0.02 | 0.02 | 0.02 | 0.02 | 0.09 | 0.04 | 1.46 | 0.74 |

**Table 8.13. Demographics of Spring Weighted Samples for Creating STEM Score Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| State — continued | | | | | | | | |
| MP | - | - | - | - | - | - | 1.33 | 0.50 |
| MS | 0.30 | 0.31 | 0.29 | 0.28 | 0.32 | 0.30 | 2.40 | 0.56 |
| MT | - | - | - | 0.01 | 0.02 | 0.35 | 0.14 | 0.12 |
| NC | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.07 |
| ND | - | - | - | 0.02 | 0.02 | 0.06 | 0.06 | 0.63 |
| NE | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.40 | 0.91 |
| NH | - | - | - | - | - | - | - | 0.01 |
| NJ | - | - | - | - | 0.01 | 0.02 | 0.05 | 0.34 |
| NM | - | - | - | - | - | - | 0.13 | 0.07 |
| NV | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.30 | 0.18 |
| NY | <0.01 | <0.01 | <0.01 | 0.01 | 0.02 | 0.02 | 0.09 | 0.22 |
| OH | - | 0.15 | 0.14 | 0.17 | 0.38 | 0.74 | 2.94 | 1.29 |
| OK | 0.20 | 0.75 | 0.80 | 0.94 | 0.90 | 1.03 | 0.96 | 0.28 |
| OR | <0.01 | <0.01 | <0.01 | 0.02 | 0.03 | 0.03 | 0.10 | 0.32 |
| PA | 0.12 | 0.12 | 0.12 | 0.1 | 0.09 | 0.09 | 0.16 | 0.43 |
| SC | 0.03 | 0.01 | 0.03 | 0.02 | 0.02 | 0.02 | 1.15 | 0.30 |
| SD | 0.08 | 0.08 | 0.09 | 0.08 | 0.18 | 0.08 | 0.05 | 0.06 |
| TN | 0.17 | 0.17 | 0.22 | 0.30 | 0.37 | 0.49 | 1.12 | 0.48 |
| TX | 0.13 | 0.27 | 0.15 | 0.19 | 0.50 | 0.37 | 0.85 | 0.39 |
| UT | 0.25 | 0.16 | 0.24 | 0.14 | 0.20 | 0.13 | 0.19 | 0.16 |
| VA | <0.01 | <0.01 | <0.01 | <0.01 | - | 0.01 | 0.05 | 0.15 |
| VI | - | - | - | - | - | - | 0.06 | 0.02 |
| WA | - | - | - | - | - | - | - | 0.05 |
| WI | 0.28 | 0.30 | 0.29 | 0.31 | 1.15 | 3.31 | 3.09 | 52.62 |
| WV | - | - | <0.01 | - | - | <0.01 | - | - |
| WY | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | <0.01 | 1.27 |
| No response | - | - | - | - | - | - | 0.08 | 0.06 |

**Table 8.13. Demographics of Spring Weighted Samples for Creating STEM Score Norms—continued**

| | Grade (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Race/Ethnicity | | | | | | | | |
| Hispanic/ Latino | 24.82 | 24.75 | 24.70 | 24.62 | 24.59 | 24.58 | 11.01 | 12.71 |
| Native American | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.69 | 0.75 |
| Asian | 4.63 | 4.63 | 4.63 | 4.65 | 4.64 | 4.64 | 2.96 | 3.45 |
| Black/African American | 14.28 | 14.26 | 14.24 | 14.22 | 14.20 | 14.20 | 13.03 | 9.72 |
| White | 46.38 | 46.35 | 46.38 | 46.33 | 46.28 | 46.29 | 51.43 | 62.41 |
| Other | 1.42 | 1.42 | 1.21 | 1.08 | 0.78 | 0.56 | 3.40 | 3.37 |
| Unknown | 7.56 | 7.68 | 7.94 | 8.18 | 8.59 | 8.80 | 17.48 | 7.60 |

*Note*. - indicates no students tested.

**Table 8.14. English Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 5 | 2 | 1 | 1 | 1 | 2 | 1 | 1 |
| 408 | 8 | 3 | 1 | 2 | 2 | 2 | 2 | 2 |
| 409 | 11 | 5 | 2 | 2 | 3 | 3 | 3 | 2 |
| 410 | 16 | 7 | 3 | 3 | 3 | 4 | 3 | 3 |
| 411 | 21 | 10 | 5 | 4 | 4 | 5 | 5 | 4 |
| 412 | 26 | 13 | 7 | 6 | 5 | 6 | 6 | 5 |
| 413 | 31 | 17 | 9 | 8 | 7 | 7 | 7 | 6 |
| 414 | 37 | 21 | 11 | 10 | 8 | 9 | 9 | 7 |
| 415 | 43 | 25 | 15 | 13 | 10 | 11 | 11 | 9 |
| 416 | 48 | 30 | 18 | 16 | 12 | 13 | 13 | 11 |
| 417 | 54 | 35 | 22 | 19 | 14 | 15 | 15 | 12 |
| 418 | 59 | 40 | 27 | 22 | 16 | 17 | 18 | 14 |
| 419 | 64 | 46 | 31 | 26 | 19 | 20 | 21 | 17 |
| 420 | 69 | 51 | 36 | 30 | 22 | 22 | 23 | 19 |
| 421 | 74 | 57 | 41 | 34 | 25 | 25 | 26 | 21 |
| 422 | 78 | 62 | 47 | 39 | 28 | 28 | 29 | 24 |
| 423 | 82 | 67 | 52 | 43 | 32 | 32 | 32 | 26 |
| 424 | 86 | 72 | 58 | 47 | 36 | 35 | 36 | 29 |
| 425 | 89 | 77 | 63 | 52 | 40 | 39 | 39 | 32 |
| 426 | 91 | 81 | 68 | 56 | 44 | 43 | 42 | 35 |
| 427 | 94 | 85 | 73 | 60 | 48 | 47 | 45 | 38 |
| 428 | 95 | 89 | 77 | 65 | 53 | 51 | 49 | 41 |
| 429 | 97 | 91 | 81 | 69 | 57 | 55 | 52 | 44 |
| 430 | 98 | 94 | 85 | 72 | 62 | 60 | 56 | 47 |

**Table 8.14. English Spring Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 96 | 88 | 76 | 66 | 64 | 59 | 50 |
| 432 | 99 | 97 | 91 | 79 | 70 | 68 | 62 | 53 |
| 433 | 99 | 98 | 93 | 82 | 74 | 72 | 65 | 56 |
| 434 | 99 | 99 | 95 | 85 | 78 | 75 | 68 | 59 |
| 435 | 100 | 99 | 96 | 88 | 81 | 79 | 72 | 62 |
| 436 | | 99 | 97 | 90 | 84 | 82 | 75 | 66 |
| 437 | | 99 | 98 | 92 | 87 | 85 | 77 | 69 |
| 438 | | 100 | 99 | 94 | 90 | 87 | 80 | 72 |
| 439 | | | 99 | 95 | 92 | 90 | 83 | 75 |
| 440 | | | 99 | 96 | 94 | 92 | 85 | 78 |
| 441 | | | 99 | 97 | 95 | 93 | 88 | 81 |
| 442 | | | 100 | 98 | 96 | 95 | 90 | 83 |
| 443 | | | | 99 | 97 | 96 | 92 | 86 |
| 444 | | | | 99 | 98 | 97 | 93 | 88 |
| 445 | | | | 99 | 99 | 98 | 95 | 91 |
| 446 | | | | 99 | 99 | 98 | 96 | 93 |
| 447 | | | | 99 | 99 | 99 | 97 | 94 |
| 448 | | | | 100 | 99 | 99 | 98 | 96 |
| 449 | | | | | 99 | 99 | 98 | 97 |
| 450 | | | | | 100 | 99 | 99 | 98 |
| 451 | | | | | | 99 | 99 | 99 |
| 452 | | | | | | 100 | 99 | 99 |
| 453 | | | | | | | 99 | 99 |
| 454 | | | | | | | 99 | 99 |
| 455 | | | | | | | 99 | 99 |
| 456 | | | | | | | 100 | 100 |

**Table 8.15. Mathematics Spring Norms: Percentage of Students at or below Each Scale**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 9 | 2 | 1 | 1 | 2 | 1 | 1 | 1 |
| 408 | 13 | 3 | 2 | 1 | 3 | 1 | 1 | 1 |
| 409 | 17 | 5 | 4 | 2 | 5 | 2 | 1 | 2 |
| 410 | 23 | 9 | 6 | 4 | 6 | 3 | 2 | 2 |
| 411 | 30 | 13 | 9 | 5 | 9 | 5 | 4 | 4 |
| 412 | 38 | 19 | 14 | 8 | 12 | 7 | 6 | 5 |
| 413 | 47 | 26 | 19 | 11 | 15 | 10 | 8 | 7 |
| 414 | 57 | 35 | 26 | 14 | 19 | 13 | 11 | 9 |
| 415 | 66 | 44 | 33 | 19 | 23 | 16 | 14 | 12 |
| 416 | 75 | 53 | 41 | 24 | 28 | 20 | 17 | 15 |
| 417 | 82 | 62 | 49 | 29 | 33 | 25 | 21 | 18 |
| 418 | 88 | 70 | 57 | 35 | 38 | 29 | 25 | 21 |
| 419 | 93 | 77 | 64 | 42 | 44 | 34 | 29 | 25 |
| 420 | 96 | 83 | 71 | 48 | 49 | 38 | 34 | 28 |
| 421 | 98 | 88 | 77 | 54 | 54 | 43 | 38 | 32 |
| 422 | 99 | 92 | 81 | 60 | 58 | 48 | 42 | 35 |
| 423 | 99 | 95 | 85 | 66 | 63 | 52 | 46 | 39 |
| 424 | 99 | 96 | 88 | 72 | 67 | 56 | 50 | 42 |
| 425 | 99 | 98 | 91 | 77 | 71 | 60 | 54 | 46 |
| 426 | 99 | 99 | 93 | 81 | 75 | 64 | 58 | 49 |
| 427 | 99 | 99 | 94 | 85 | 78 | 68 | 62 | 53 |
| 428 | 99 | 99 | 96 | 88 | 81 | 71 | 66 | 56 |
| 429 | 99 | 99 | 97 | 90 | 84 | 74 | 69 | 60 |
| 430 | 99 | 99 | 97 | 93 | 86 | 77 | 72 | 63 |

Table 8.15. Mathematics Spring Norms: Percentage of Students at or below Each Scale Score—continued

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 98 | 94 | 88 | 80 | 75 | 66 |
| 432 | 99 | 99 | 98 | 96 | 90 | 83 | 78 | 69 |
| 433 | 99 | 99 | 99 | 97 | 92 | 85 | 81 | 73 |
| 434 | 100 | 99 | 99 | 98 | 94 | 87 | 84 | 76 |
| 435 | | 99 | 99 | 98 | 95 | 89 | 86 | 79 |
| 436 | | 99 | 99 | 99 | 96 | 91 | 88 | 82 |
| 437 | | 99 | 99 | 99 | 97 | 93 | 90 | 84 |
| 438 | | 99 | 99 | 99 | 98 | 94 | 92 | 87 |
| 439 | | 99 | 99 | 99 | 99 | 96 | 94 | 89 |
| 440 | | 100 | 99 | 99 | 99 | 97 | 95 | 91 |
| 441 | | | 99 | 99 | 99 | 98 | 96 | 93 |
| 442 | | | 99 | 99 | 99 | 98 | 97 | 95 |
| 443 | | | 99 | 99 | 99 | 99 | 98 | 96 |
| 444 | | | 99 | 99 | 99 | 99 | 99 | 97 |
| 445 | | | 99 | 99 | 99 | 99 | 99 | 98 |
| 446 | | | 100 | 99 | 99 | 99 | 99 | 99 |
| 447 | | | | 99 | 99 | 99 | 99 | 99 |
| 448 | | | | 99 | 99 | 99 | 99 | 99 |
| 449 | | | | 99 | 99 | 99 | 99 | 99 |
| 450 | | | | 99 | 99 | 99 | 99 | 99 |
| 451 | | | | 100 | 99 | 99 | 99 | 99 |
| 452 | | | | | 99 | 99 | 99 | 99 |
| 453 | | | | | 100 | 99 | 99 | 99 |
| 454 | | | | | | 99 | 99 | 99 |
| 455 | | | | | | 99 | 99 | 99 |
| 456 | | | | | | 100 | 99 | 99 |
| 457 | | | | | | | 99 | 99 |
| 458 | | | | | | | 99 | 99 |
| 459 | | | | | | | 99 | 99 |
| 460 | | | | | | | 100 | 100 |

**Table 8.16. Reading Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 7 | 4 | 2 | 1 | 1 | 1 | 1 | 1 |
| 406 | 12 | 7 | 4 | 2 | 2 | 1 | 1 | 1 |
| 407 | 19 | 10 | 6 | 4 | 3 | 2 | 2 | 2 |
| 408 | 25 | 14 | 8 | 6 | 4 | 3 | 3 | 3 |
| 409 | 32 | 18 | 12 | 9 | 7 | 5 | 5 | 5 |
| 410 | 38 | 23 | 16 | 12 | 9 | 6 | 7 | 7 |
| 411 | 43 | 28 | 20 | 15 | 12 | 8 | 9 | 9 |
| 412 | 49 | 33 | 24 | 19 | 15 | 11 | 12 | 12 |
| 413 | 54 | 38 | 29 | 23 | 19 | 13 | 16 | 15 |
| 414 | 60 | 44 | 34 | 27 | 22 | 16 | 19 | 18 |
| 415 | 65 | 50 | 39 | 31 | 26 | 18 | 23 | 21 |
| 416 | 71 | 55 | 45 | 36 | 30 | 21 | 26 | 24 |
| 417 | 76 | 61 | 50 | 40 | 34 | 25 | 30 | 27 |
| 418 | 81 | 67 | 55 | 45 | 39 | 28 | 34 | 30 |
| 419 | 86 | 72 | 60 | 50 | 44 | 32 | 38 | 33 |
| 420 | 90 | 77 | 66 | 55 | 49 | 36 | 41 | 37 |
| 421 | 93 | 82 | 71 | 59 | 54 | 40 | 45 | 40 |
| 422 | 95 | 86 | 75 | 64 | 60 | 44 | 49 | 43 |
| 423 | 97 | 89 | 80 | 69 | 66 | 49 | 53 | 47 |
| 424 | 98 | 92 | 84 | 74 | 71 | 54 | 57 | 51 |
| 425 | 99 | 94 | 88 | 78 | 77 | 59 | 61 | 54 |
| 426 | 99 | 96 | 91 | 83 | 82 | 65 | 65 | 58 |
| 427 | 99 | 97 | 94 | 87 | 86 | 70 | 69 | 63 |
| 428 | 99 | 98 | 96 | 90 | 90 | 75 | 73 | 67 |
| 429 | 100 | 99 | 97 | 93 | 93 | 80 | 77 | 72 |
| 430 | | 99 | 98 | 96 | 95 | 85 | 82 | 76 |

**Table 8.16. Reading Spring Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | | 100 | 99 | 97 | 97 | 89 | 85 | 81 |
| 432 | | | 99 | 98 | 98 | 92 | 89 | 85 |
| 433 | | | 99 | 99 | 99 | 95 | 92 | 89 |
| 434 | | | 100 | 99 | 99 | 97 | 95 | 93 |
| 435 | | | | 99 | 99 | 98 | 97 | 95 |
| 436 | | | | 100 | 99 | 99 | 98 | 97 |
| 437 | | | | | 99 | 99 | 99 | 99 |
| 438 | | | | | 100 | 99 | 99 | 99 |
| 439 | | | | | | 99 | 99 | 99 |
| 440 | | | | | | 100 | 99 | 99 |
| 441 | | | | | | | 99 | 99 |
| 442 | | | | | | | 100 | 100 |

**Table 8.17. Science Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 6 | 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 10 | 5 | 2 | 2 | 2 | 1 | 1 | 1 |
| 407 | 14 | 7 | 3 | 3 | 3 | 1 | 1 | 1 |
| 408 | 19 | 9 | 4 | 4 | 4 | 2 | 1 | 2 |
| 409 | 23 | 12 | 6 | 6 | 6 | 4 | 2 | 2 |
| 410 | 28 | 16 | 9 | 8 | 8 | 5 | 3 | 3 |
| 411 | 33 | 19 | 11 | 10 | 10 | 7 | 5 | 5 |
| 412 | 37 | 23 | 15 | 13 | 13 | 9 | 6 | 6 |
| 413 | 42 | 27 | 18 | 16 | 15 | 11 | 8 | 8 |
| 414 | 46 | 31 | 22 | 19 | 18 | 14 | 11 | 10 |
| 415 | 50 | 36 | 26 | 23 | 22 | 17 | 13 | 12 |
| 416 | 55 | 41 | 30 | 26 | 25 | 20 | 16 | 15 |
| 417 | 60 | 46 | 35 | 30 | 28 | 23 | 20 | 18 |
| 418 | 64 | 51 | 39 | 35 | 32 | 26 | 23 | 21 |
| 419 | 69 | 57 | 45 | 39 | 36 | 29 | 27 | 24 |
| 420 | 74 | 62 | 50 | 44 | 39 | 33 | 31 | 27 |
| 421 | 78 | 68 | 56 | 48 | 43 | 37 | 35 | 31 |
| 422 | 83 | 73 | 62 | 53 | 48 | 41 | 39 | 34 |
| 423 | 87 | 78 | 67 | 59 | 52 | 45 | 42 | 37 |
| 424 | 90 | 82 | 73 | 64 | 56 | 49 | 46 | 41 |
| 425 | 93 | 86 | 78 | 69 | 61 | 53 | 50 | 44 |
| 426 | 95 | 90 | 83 | 74 | 65 | 57 | 54 | 47 |
| 427 | 97 | 92 | 87 | 79 | 70 | 62 | 58 | 51 |
| 428 | 98 | 95 | 90 | 83 | 74 | 66 | 61 | 54 |
| 429 | 99 | 96 | 93 | 87 | 78 | 71 | 65 | 57 |
| 430 | 99 | 97 | 95 | 90 | 82 | 75 | 68 | 60 |

**Table 8.17. Science Spring Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 98 | 97 | 93 | 86 | 79 | 72 | 64 |
| 432 | 99 | 99 | 98 | 95 | 89 | 82 | 75 | 67 |
| 433 | 100 | 99 | 98 | 96 | 92 | 86 | 78 | 70 |
| 434 | | 99 | 99 | 98 | 94 | 89 | 81 | 74 |
| 435 | | 99 | 99 | 98 | 96 | 91 | 84 | 77 |
| 436 | | 100 | 99 | 99 | 97 | 93 | 87 | 80 |
| 437 | | | 99 | 99 | 98 | 95 | 90 | 83 |
| 438 | | | 100 | 99 | 99 | 96 | 92 | 86 |
| 439 | | | | 99 | 99 | 97 | 94 | 89 |
| 440 | | | | 100 | 99 | 98 | 96 | 92 |
| 441 | | | | | 99 | 99 | 97 | 94 |
| 442 | | | | | 99 | 99 | 98 | 96 |
| 443 | | | | | 100 | 99 | 99 | 97 |
| 444 | | | | | | 99 | 99 | 98 |
| 445 | | | | | | 99 | 99 | 99 |
| 446 | | | | | | 100 | 99 | 99 |
| 447 | | | | | | | 99 | 99 |
| 448 | | | | | | | 99 | 99 |
| 449 | | | | | | | 100 | 100 |

**Table 8.18. Composite Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 7 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 12 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| 409 | 18 | 6 | 3 | 2 | 2 | 1 | 1 | 1 |
| 410 | 24 | 10 | 5 | 3 | 3 | 2 | 1 | 1 |
| 411 | 30 | 15 | 7 | 5 | 5 | 3 | 2 | 2 |
| 412 | 36 | 20 | 11 | 8 | 7 | 5 | 4 | 3 |
| 413 | 43 | 25 | 15 | 11 | 10 | 7 | 6 | 5 |
| 414 | 49 | 31 | 20 | 15 | 13 | 9 | 8 | 7 |
| 415 | 55 | 37 | 25 | 19 | 16 | 12 | 11 | 10 |
| 416 | 61 | 43 | 31 | 23 | 20 | 15 | 15 | 13 |
| 417 | 67 | 49 | 37 | 28 | 24 | 19 | 19 | 16 |
| 418 | 73 | 56 | 43 | 33 | 28 | 23 | 22 | 19 |
| 419 | 78 | 62 | 49 | 38 | 33 | 26 | 26 | 23 |
| 420 | 84 | 68 | 55 | 43 | 37 | 30 | 30 | 26 |
| 421 | 88 | 74 | 61 | 48 | 42 | 35 | 34 | 29 |
| 422 | 92 | 80 | 67 | 53 | 47 | 39 | 38 | 33 |
| 423 | 95 | 85 | 73 | 59 | 52 | 43 | 42 | 36 |
| 424 | 97 | 89 | 78 | 64 | 56 | 48 | 46 | 39 |
| 425 | 98 | 93 | 83 | 69 | 61 | 52 | 50 | 43 |
| 426 | 99 | 95 | 87 | 74 | 66 | 57 | 54 | 46 |
| 427 | 99 | 97 | 91 | 79 | 70 | 61 | 58 | 50 |
| 428 | 99 | 98 | 93 | 83 | 75 | 66 | 61 | 53 |
| 429 | 99 | 99 | 96 | 87 | 79 | 70 | 65 | 56 |
| 430 | 99 | 99 | 97 | 90 | 83 | 74 | 69 | 60 |

**Table 8.18. Composite Spring Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 98 | 93 | 87 | 79 | 73 | 64 |
| 432 | 99 | 99 | 99 | 95 | 90 | 82 | 76 | 67 |
| 433 | 100 | 99 | 99 | 97 | 93 | 86 | 80 | 71 |
| 434 | | 99 | 99 | 98 | 95 | 89 | 83 | 75 |
| 435 | | 99 | 99 | 99 | 97 | 92 | 86 | 79 |
| 436 | | 100 | 99 | 99 | 98 | 94 | 89 | 82 |
| 437 | | | 99 | 99 | 99 | 96 | 92 | 86 |
| 438 | | | 99 | 99 | 99 | 97 | 94 | 89 |
| 439 | | | 99 | 99 | 99 | 98 | 96 | 92 |
| 440 | | | 100 | 99 | 99 | 99 | 97 | 94 |
| 441 | | | | 99 | 99 | 99 | 98 | 96 |
| 442 | | | | 99 | 99 | 99 | 99 | 97 |
| 443 | | | | 99 | 99 | 99 | 99 | 98 |
| 444 | | | | 100 | 99 | 99 | 99 | 99 |
| 445 | | | | | 99 | 99 | 99 | 99 |
| 446 | | | | | 100 | 99 | 99 | 99 |
| 447 | | | | | | 99 | 99 | 99 |
| 448 | | | | | | 99 | 99 | 99 |
| 449 | | | | | | 100 | 99 | 99 |
| 450 | | | | | | | 99 | 99 |
| 451 | | | | | | | 99 | 99 |
| 452 | | | | | | | 100 | 100 |

**Table 8.19. ELA Score Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 409 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 410 | 8 | 3 | 2 | 1 | 2 | 2 | 1 | 1 |
| 411 | 12 | 5 | 3 | 2 | 3 | 2 | 2 | 2 |
| 412 | 17 | 8 | 5 | 3 | 4 | 3 | 4 | 3 |
| 413 | 23 | 11 | 7 | 5 | 6 | 5 | 5 | 4 |
| 414 | 29 | 15 | 10 | 7 | 8 | 6 | 7 | 6 |
| 415 | 36 | 19 | 14 | 9 | 11 | 8 | 9 | 8 |
| 416 | 42 | 24 | 18 | 12 | 13 | 11 | 12 | 10 |
| 417 | 49 | 30 | 23 | 15 | 17 | 13 | 14 | 12 |
| 418 | 56 | 36 | 28 | 19 | 20 | 16 | 17 | 15 |
| 419 | 63 | 42 | 33 | 23 | 24 | 20 | 21 | 18 |
| 420 | 70 | 49 | 39 | 27 | 29 | 23 | 24 | 20 |
| 421 | 76 | 57 | 45 | 32 | 33 | 27 | 28 | 23 |
| 422 | 81 | 64 | 51 | 37 | 38 | 32 | 31 | 26 |
| 423 | 86 | 71 | 57 | 42 | 43 | 36 | 35 | 30 |
| 424 | 90 | 77 | 63 | 48 | 49 | 41 | 39 | 33 |
| 425 | 93 | 83 | 69 | 54 | 54 | 47 | 44 | 37 |
| 426 | 95 | 88 | 74 | 60 | 60 | 52 | 48 | 41 |
| 427 | 97 | 92 | 79 | 66 | 66 | 58 | 53 | 45 |
| 428 | 98 | 95 | 84 | 72 | 71 | 63 | 57 | 49 |
| 429 | 99 | 97 | 88 | 77 | 77 | 69 | 62 | 54 |
| 430 | 99 | 98 | 91 | 82 | 81 | 74 | 67 | 58 |

**Table 8.19. ELA Score Spring Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 94 | 86 | 86 | 79 | 72 | 63 |
| 432 | 99 | 99 | 96 | 90 | 89 | 84 | 76 | 68 |
| 433 | 99 | 99 | 98 | 93 | 92 | 88 | 81 | 74 |
| 434 | 99 | 99 | 99 | 95 | 95 | 91 | 85 | 79 |
| 435 | 100 | 99 | 99 | 97 | 97 | 94 | 89 | 83 |
| 436 | | 100 | 99 | 98 | 98 | 96 | 92 | 87 |
| 437 | | | 99 | 99 | 99 | 97 | 95 | 91 |
| 438 | | | 99 | 99 | 99 | 98 | 97 | 94 |
| 439 | | | 100 | 99 | 99 | 99 | 98 | 96 |
| 440 | | | | 99 | 99 | 99 | 99 | 98 |
| 441 | | | | 99 | 99 | 99 | 99 | 99 |
| 442 | | | | 99 | 99 | 99 | 99 | 99 |
| 443 | | | | 99 | 99 | 99 | 99 | 99 |
| 444 | | | | 100 | 99 | 99 | 99 | 99 |
| 445 | | | | | 100 | 99 | 99 | 99 |
| 446 | | | | | | 99 | 99 | 99 |
| 447 | | | | | | 100 | 99 | 99 |
| 448 | | | | | | | 99 | 99 |
| 449 | | | | | | | 100 | 100 |

**Table 8.20. STEM Score Spring Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 10 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 14 | 4 | 2 | 1 | 2 | 1 | 1 | 1 |
| 409 | 19 | 7 | 3 | 2 | 3 | 1 | 1 | 1 |
| 410 | 24 | 10 | 5 | 4 | 5 | 2 | 1 | 1 |
| 411 | 30 | 15 | 8 | 6 | 7 | 4 | 2 | 2 |
| 412 | 36 | 19 | 11 | 8 | 10 | 5 | 3 | 3 |
| 413 | 42 | 25 | 16 | 11 | 13 | 8 | 5 | 5 |
| 414 | 48 | 31 | 21 | 15 | 16 | 11 | 8 | 7 |
| 415 | 54 | 38 | 26 | 19 | 20 | 14 | 11 | 10 |
| 416 | 61 | 44 | 32 | 24 | 25 | 17 | 14 | 13 |
| 417 | 68 | 51 | 39 | 28 | 29 | 21 | 18 | 16 |
| 418 | 74 | 58 | 46 | 34 | 34 | 25 | 22 | 19 |
| 419 | 80 | 65 | 52 | 39 | 38 | 30 | 26 | 23 |
| 420 | 85 | 71 | 59 | 45 | 43 | 34 | 30 | 26 |
| 421 | 90 | 77 | 65 | 50 | 48 | 38 | 35 | 30 |
| 422 | 93 | 83 | 71 | 56 | 52 | 43 | 39 | 34 |
| 423 | 96 | 87 | 77 | 62 | 57 | 47 | 43 | 37 |
| 424 | 98 | 91 | 81 | 67 | 61 | 52 | 47 | 41 |
| 425 | 99 | 94 | 86 | 73 | 66 | 56 | 51 | 44 |
| 426 | 99 | 96 | 89 | 78 | 70 | 60 | 55 | 48 |
| 427 | 99 | 98 | 92 | 82 | 74 | 64 | 59 | 51 |
| 428 | 99 | 99 | 94 | 86 | 78 | 68 | 63 | 54 |
| 429 | 99 | 99 | 96 | 89 | 81 | 72 | 66 | 58 |
| 430 | 99 | 99 | 97 | 92 | 85 | 76 | 70 | 61 |

Table 8.20. STEM Score Spring Norms: Percentage of Students at or below Each Scale Score—continued

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 98 | 94 | 88 | 79 | 73 | 64 |
| 432 | 99 | 99 | 99 | 96 | 90 | 82 | 77 | 68 |
| 433 | 99 | 99 | 99 | 97 | 93 | 86 | 80 | 71 |
| 434 | 100 | 99 | 99 | 98 | 95 | 88 | 83 | 74 |
| 435 | | 99 | 99 | 99 | 96 | 91 | 86 | 78 |
| 436 | | 99 | 99 | 99 | 97 | 93 | 88 | 81 |
| 437 | | 99 | 99 | 99 | 98 | 95 | 91 | 84 |
| 438 | | 100 | 99 | 99 | 99 | 96 | 93 | 87 |
| 439 | | | 99 | 99 | 99 | 97 | 94 | 89 |
| 440 | | | 99 | 99 | 99 | 98 | 96 | 92 |
| 441 | | | 99 | 99 | 99 | 99 | 97 | 94 |
| 442 | | | 100 | 99 | 99 | 99 | 98 | 96 |
| 443 | | | | 99 | 99 | 99 | 99 | 97 |
| 444 | | | | 99 | 99 | 99 | 99 | 98 |
| 445 | | | | 99 | 99 | 99 | 99 | 99 |
| 446 | | | | 100 | 99 | 99 | 99 | 99 |
| 447 | | | | | 99 | 99 | 99 | 99 |
| 448 | | | | | 100 | 99 | 99 | 99 |
| 449 | | | | | | 99 | 99 | 99 |
| 450 | | | | | | 99 | 99 | 99 |
| 451 | | | | | | 100 | 99 | 99 |
| 452 | | | | | | | 99 | 99 |
| 453 | | | | | | | 99 | 99 |
| 454 | | | | | | | 99 | 99 |
| 455 | | | | | | | 100 | 100 |

**Table 8.21. National Average Scale Scores Based on Spring Norm Samples**

| | Subject/Reported Score | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | Composite | ELA | STEM |
| 3 | 417 | 414 | 413 | 415 | 415 | 418 | 415 |
| 4 | 420 | 416 | 416 | 418 | 418 | 420 | 417 |
| 5 | 423 | 418 | 418 | 420 | 420 | 422 | 419 |
| 6 | 425 | 421 | 419 | 421 | 422 | 425 | 421 |
| 7 | 427 | 421 | 420 | 423 | 423 | 424 | 422 |
| 8 | 428 | 424 | 423 | 424 | 425 | 426 | 424 |
| 9 | 429 | 425 | 422 | 426 | 426 | 426 | 426 |
| 10 | 431 | 427 | 423 | 427 | 427 | 428 | 427 |

**Table 8.22. Percentage of Students Who Met Benchmark in Spring Norm Samples**

| | Subject/Reported Score | | | | | |
|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | ELA | STEM |
| 3 | 74 | 62 | 40 | 40 | 44 | 20 |
| 4 | 70 | 56 | 45 | 43 | 43 | 23 |
| 5 | 73 | 51 | 40 | 44 | 43 | 19 |
| 6 | 74 | 58 | 45 | 47 | 46 | 18 |
| 7 | 78 | 46 | 40 | 44 | 46 | 19 |
| 8 | 75 | 44 | 51 | 43 | 48 | 18 |
| 9 | 61 | 38 | 43 | 35 | 47 | 17 |
| 10 | 62 | 34 | 37 | 36 | 46 | 19 |

*Note*. Benchmark is not available for ACT Aspire Composite score.

## 8.4.1.3 Weighting Methodology for ACT Aspire Spring Norms

Students assessed with ACT Aspire are not representative of the national population of U.S. elementary and secondary school students. To support interpretations of nationally representative norms, weights were assigned to the ACT Aspire–tested samples so that the weighted samples are similar to the national population of U.S. elementary and secondary school students on school affiliation (public vs. private), and, among public school students, race/ethnicity and academic achievement.

For grades 3–8, first, the population of U.S. elementary and secondary public school students was estimated with respect to race/ethnicity and district mean achievement level. Then, the public school ACT Aspire–tested students were weighted to match on these characteristics. Finally, the weighted public school data were combined with the private school data, and the final weighting reflects the frequency of school affiliation (public or private) in the population. An important assumption of this approach is that a district's mean achievement level can be measured by its mean ACT Composite score[2] and that this measure is related to achievement in the lower grades. To examine this assumption, we computed correlations between district mean ACT Composite scores and district mean ACT Aspire scores across grade levels. As examples, Table 8.23 presents correlations based on three-year rolling norm data up to the 2018–2019 academic year. Across subjects and grades, district mean ACT Composite scores are moderately to highly correlated with district mean ACT Aspire scores. The correlations in Table 8.23 suggested that district mean ACT Composite scores are related to achievement in lower grades.

**Table 8.23. Correlation of District Mean ACT Composite Scores with District Mean ACT Aspire Score**

| | Subject | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | Composite | ELA | STEM |
| 3 | 0.63 | 0.60 | 0.71 | 0.57 | | 0.63 | 0.56 |
| 4 | 0.62 | 0.64 | 0.71 | 0.61 | | 0.61 | 0.60 |
| 5 | 0.60 | 0.67 | 0.70 | 0.66 | | 0.67 | 0.68 |
| 6 | 0.63 | 0.56 | 0.63 | 0.57 | | 0.62 | 0.56 |
| 7 | 0.64 | 0.67 | 0.59 | 0.57 | | 0.64 | 0.62 |
| 8 | 0.67 | 0.69 | 0.58 | 0.61 | 0.64 | 0.60 | 0.66 |
| 9 | 0.66 | 0.76 | 0.69 | 0.68 | 0.72 | 0.66 | 0.74 |
| 10 | 0.73 | 0.80 | 0.67 | 0.72 | 0.78 | 0.71 | 0.78 |

*Note*. Districts with at least 50 ACT Aspire–tested students were included.

For grade 9, a sample of students tested with ACT Aspire in grades 8 and 9 was used. After the norms were developed for grade 8, the longitudinal samples (one for each subject) were weighted to match the national grade 8 score distribution. The weighted score distributions of the grade 9 scores were then calculated. For grade 10, the same approach was used, but the national grade 9 score distribution served as the anchor.

The weighting procedure for grades 3–8 is described in detail below. In what follows, target population

[2] When a district tests virtually all students with the ACT, as is often done with ACT state and district testing, a district's mean ACT Composite score measures the mean achievement level of the district's graduating students.

refers to the population of U.S. elementary and secondary school students. The following steps were taken to weight each ACT Aspire norming sample:[3]

1. Determine the target population's relative frequency of students enrolled in public and private schools.[4]
2. Among public school students within the target population, determine the relative frequency by race ethnicity and school percent eligible for free or reduced lunch (school FRL). Table 8.24 shows the categorizations of these variables and relative frequencies in the public school target population.[5]
3. Identify all public school districts that administer the ACT test to all grade 11 students; we refer to ACT-tested students within these districts as the ACT state and district testing public school sample. Weight this sample to the public school target population on race/ethnicity and school FRL. Weights were determined by the ratio of the population and sample percentages of each combination of race/ethnicity and school FRL:

$$weight(Race = x, FRL = y) = \frac{Pop.\%(Race = x, FRL = y)}{Sample\ \%(Race = x, FRL = y)}.$$

We refer to this weighted sample as the ACT public school population. The ACT public school population was nearly identical to the public school target population with respect to relative frequencies of race/ethnicity and school FRL groups (Table 8.24).

4. For each student in the ACT public school population, determine the mean ACT Composite score within their district. Categorize district mean ACT score[6] and student race/ethnicity, and calculate the relative frequency of each combination of race/ethnicity and district mean ACT Composite score level (DMACT) within the ACT public school population.
5. For each ACT Aspire norm sample, determine public/private school affiliation and, for public school students, race/ethnicity and DMACT. For students enrolled in public schools, calculate the sample percentage for each combination of race/ ethnicity and DMACT. Weight the sample to the target population on public/private school affiliation and, for public school students, race/ethnicity and DMACT. Weights were determined by the ratio of the population and sample percentages:

$$Public\ weight(Race = x, DMACT = y) = \frac{Pop.\%\ public}{Sample\ \%\ public} \times \frac{ACT\ Public\ Pop.\%(Race = x, DMACT = y)}{Public\ Sample\ \%(Race = x, DMACT = y)}$$ and

$$Private\ weight = \frac{Pop.\ \%\ private}{Sample\ \%\ private}.$$

[3] There is one norming sample for each grade and subject.
[4] Estimated from market data retrieval data, the target population includes 90.5% public-school and 9.5% private-school students.
[5] The public school target population relative frequencies for race/ethnicity and school FRL were derived from the Common Core of Public School Universe Survey Data provided by the National Center for Education Statistics.
[6] See Table 8.24 for the categorization of district mean ACT Composite score.

For an example norm sample (grade 5 English), the relative frequencies of the weighting variables are provided in Table 8.25 for the target population, the ACT public school population, the unweighted sample, and the weighted sample. The weighted sample was identical to the target population with respect to school affiliation, and the public school sample was identical to the ACT public school population on race/ethnicity and district mean ACT Composite score. As shown in Table 8.25, the weighted district mean ACT Composite score was higher than the unweighted district mean ACT Composite score, but the weighted mean ACT Aspire grade 5 English score was lower than the unweighted mean. This discrepancy shows that other weighting variables (i.e., race or school affiliation) likely affect the score distribution in a different direction.

**Table 8.24. Target Public School Population and ACT Public School Population**

| | | ACT state and district testing public school sample | |
|---|---|---|---|
| Variable | Population of public U.S. elementary and secondary students | Unweighted | ACT public school population[a] |
| Race/ethnicity | | | |
| Asian | 5.0% | 3.0% | 5.0% |
| Black/African American | 15.3% | 14.5% | 15.3% |
| Hispanic | 26.4% | 12.3% | 26.4% |
| Native American | 1.0% | 0.9% | 1.0% |
| White | 48.5% | 53.8% | 48.5% |
| Unknown/Other[b] | 3.8% | 15.4% | 3.8% |
| FRL % of enrolled school | | | |
| 0–10% | 6.4% | 3.8% | 6.4% |
| 10–20% | 8.5% | 12.1% | 8.5% |
| 20–35% | 14.4% | 20.8% | 14.4% |
| 35–50% | 16.8% | 25.5% | 16.8% |
| 50–65% | 16.6% | 19.9% | 16.6% |
| 65–80% | 14.1% | 8.6% | 14.1% |
| 80–90% | 9.5% | 3.1% | 9.5% |
| 90–100% | 11.0% | 5.6% | 11.0% |
| Unknown | 2.8% | 0.7% | 2.8% |

**Table 8.24. Target Public School Population and ACT Public School Population—continued**

| Variable | Population of public U.S. elementary and secondary students | ACT state and district testing public school sample: Unweighted | ACT state and district testing public school sample: ACT public school population[a] |
|---|---|---|---|
| District mean ACT score | | | |
| <16.50 | | 5.3% | 9.7% |
| 16.50–17.41 | | 6.6% | 10.1% |
| 17.41–17.73 | | 7.3% | 10.1% |
| 17.73–18.34 | | 11.3% | 10.6% |
| 18.34–18.85 | | 10.5% | 9.9% |
| 18.85–19.30 | | 10.5% | 9.6% |
| 19.30–19.89 | | 12.0% | 9.9% |
| 19.89–20.59 | | 12.9% | 10.0% |
| 20.59–21.83 | | 13.4% | 10.0% |
| >21.83 | | 10.3% | 10.0% |
| Mean (SD) district mean ACT score | | 19.4 (2.4) | 18.9 (2.8) |
| Mean (SD) ACT Composite score | | 19.4 (5.4) | 18.9 (5.4) |

*Note*. Shading represents variables used in weighting.
[a]ACT state and district testing public school sample weighted to national population of U.S. elementary and secondary students on race/ethnicity and school FRL. [b]For the public school target population, the relative frequency for Unknown/Other is obtained by subtracting the sum of the individual race/ethnicity counts from total enrollment counts. For the ACT data, the unknown/other category includes Native Hawaiian/Other Pacific Islander, two or more races, prefer not to respond, and no response.

**Table 8.25. An Example of ACT Aspire Spring Norm Sample Weighting: Grade 5 English**

| Variable | Population of public U.S. elementary and secondary students | ACT public school population[a] | ACT Aspire norm sample: grade 5 English | |
|---|---|---|---|---|
| | | | Unweighted | ACT public school population[a] |
| Sex | | | | |
| Female | 48.6% | 50.6% | 49.0% | 49.0% |
| Male | 51.4% | 48.7% | 50.4% | 50.7% |
| Unknown | | 0.7% | 0.6% | 0.3% |
| School affiliation | | | | |
| Public | 90.5% | | 78.0% | 90.5% |
| Private | 9.5% | | 22.0% | 9.5% |
| Public school frequencies | | | | |
| Race/ethnicity | | | | |
| Asian | 5.0% | 5.0% | 1.5% | 5.0% |
| Black/African American | 15.3% | 15.3% | 23.5% | 15.3% |
| Hispanic | 26.4% | 26.4% | 11.3% | 26.4% |
| Native American | 1.0% | 1.0% | 0.8% | 1.0% |
| White | 48.5% | 48.5% | 56.7% | 48.5% |
| Unknown/Other | 3.8% | 3.8% | 6.2% | 3.8% |
| FRL % of enrolled school | | | | |
| 0–10% | 6.4% | 6.4% | 0.9% | 1.1% |
| 10–20% | 8.5% | 8.5% | 1.2% | 1.5% |
| 20–35% | 14.4% | 14.4% | 8.6% | 12.0% |
| 35–50% | 16.8% | 16.8% | 16.0% | 16.4% |
| 50–65% | 16.6% | 16.6% | 25.4% | 23.7% |
| 65–80% | 14.1% | 14.1% | 26.6% | 24.1% |
| 80–90% | 9.5% | 9.5% | 7.3% | 7.9% |
| 90–100% | 11.0% | 11.0% | 11.2% | 9.7% |
| Unknown | 2.8% | 2.8% | 2.7% | 3.6% |

**Table 8.25. An Example of ACT Aspire Spring Norm Sample Weighting: Grade 5 English—continued**

| Variable | Population of public U.S. elementary and secondary students | ACT public school population[a] | ACT Aspire norm sample: grade 5 English — Unweighted | ACT Aspire norm sample: grade 5 English — ACT public school population[a] |
|---|---|---|---|---|
| District mean ACT score | | | | |
| <16.50 | | 9.9% | 11.6% | 9.9% |
| 16.50–17.41 | | 10.0% | 8.1% | 10.0% |
| 17.41–17.73 | | 10.1% | 8.6% | 10.1% |
| 17.73–18.34 | | 10.3% | 11.8% | 10.3% |
| 18.34–18.85 | | 9.6% | 12.1% | 9.6% |
| 18.85–19.30 | | 10.1% | 12.3% | 10.1% |
| 19.30–19.89 | | 10.0% | 11.2% | 10.0% |
| 19.89–20.59 | | 10.0% | 12.9% | 10.0% |
| 20.59–21.83 | | 10.0% | 8.0% | 10.0% |
| >21.83 | | 10.0% | 3.4% | 10.0% |
| Mean (SD) district mean ACT score | | 18.9 (2.8) | 18.7 (1.7) | 18.9 (2.1) |
| Mean (SD) ACT Aspire score | | | 423.4 (7.0) | 423.1 (7.0) |

*Note*. Shading represents variables used in weighting.
[a]ACT state and district testing public school sample weighted to national population of U.S. elementary and secondary students on race/ethnicity and school FRL.

To illustrate the weighting process for grade 9, the relative frequencies of the weighting variables are provided for mathematics for the target population, the ACT public school population, the grade 8 weighted sample, the grade 9 unweighted sample, and the grade 9 weighted sample (Table 8.26). The grade 9 weighted sample was identical to the grade 8 weighted sample with respect to grade 8 ACT Aspire mathematics score categories. In turn, the grade 8 weighted sample was identical to the target population with respect to school affiliation, and the public school sample was identical to the ACT public school population on race/ethnicity and district mean ACT Composite score.

**Table 8.26. An Example of ACT Aspire Spring Norm Sample Weighting: Grade 9 Mathematics**

| Variable | Population of public U.S. elementary and secondary students | ACT public school population[a] | ACT Aspire norm sample: grade 8 mathematics, weighted | ACT Aspire norm sample: grade 9 mathematics | |
|---|---|---|---|---|---|
| | | | | Unweighted | Weighted |
| Sex | | | | | |
| Female | 48.6% | 50.6% | 49.0% | 49.4% | 49.2% |
| Male | 51.4% | 48.7% | 50.7% | 50.3% | 50.4% |
| Unknown | | 0.7% | 0.3% | 0.4% | 0.4% |
| School affiliation | | | | | |
| Public | 90.5% | | 90.5% | 81.7% | 84.6% |
| Private | 9.5% | | 9.5% | 14.1% | 12.3% |
| Unknown | | | | 4.2% | 3.1% |
| Grade 8 ACT Aspire score range | | | | | |
| 400–403 | | | 0.1% | 0.1% | 0.1% |
| 404–406 | | | 0.4% | 0.4% | 0.4% |
| 407–409 | | | 1.9% | 1.8% | 1.9% |
| 410–412 | | | 5.3% | 4.7% | 5.3% |
| 413–415 | | | 9.9% | 10.4% | 9.9% |
| 416–418 | | | 13.6% | 13.7% | 13.6% |
| 419–421 | | | 14.6% | 14.1% | 14.6% |
| 422–424 | | | 13.4% | 14.3% | 13.4% |
| 425–427 | | | 11.2% | 12.3% | 11.2% |
| 428–430 | | | 9.0% | 8.8% | 9.0% |
| 431–433 | | | 7.2% | 7.2% | 7.2% |
| 434–436 | | | 5.6% | 5.3% | 5.6% |
| 437–439 | | | 4.0% | 3.9% | 4.0% |
| 440–442 | | | 2.5% | 2.2% | 2.5% |
| 443–445 | | | 1.1% | 0.6% | 1.1% |
| 446–448 | | | 0.3% | 0.2% | 0.3% |
| 449–451 | | | 0.0% | 0.0% | 0.0% |
| 452–454 | | | 0.0% | 0.0% | 0.0% |
| 455–456 | | | 0.0% | 0.0% | 0.0% |
| Mean (SD) grade 8 ACT Aspire score | | | 423.4 (8.3) | 423.2 (8.0) | 423.4 (8.3) |

**Table 8.26. An Example of ACT Aspire Spring Norm Sample Weighting: Grade 9 Mathematics—continued**

| Variable | Population of public U.S. elementary and secondary students | ACT public school population[a] | ACT Aspire norm sample: grade 8 mathematics, weighted | ACT Aspire norm sample: grade 9 mathematics | |
|---|---|---|---|---|---|
| | | | | Unweighted | Weighted |
| Public school frequencies | | | | | |
| Race/ethnicity | | | | | |
| Asian | 5.0% | 5.0% | 5.0% | 2.8% | 2.9% |
| Black/African American | 15.3% | 15.3% | 15.3% | 12.1% | 12.1% |
| Hispanic | 26.4% | 26.4% | 26.4% | 10.4% | 10.4% |
| Native American | 1.0% | 1.0% | 1.0% | 0.7% | 0.7% |
| White | 48.5% | 48.5% | 48.5% | 47.3% | 47.3% |
| Unknown/Other | 3.8% | 3.8% | 3.8% | 23.6% | 23.6% |
| FRL % of enrolled school | | | | | |
| 0–10% | 6.4% | 6.4% | 1.5% | 1.5% | 1.5% |
| 10–20% | 8.5% | 8.5% | 5.4% | 6.1% | 6.3% |
| 20–35% | 14.4% | 14.4% | 13.8% | 11.7% | 11.8% |
| 35–50% | 16.8% | 16.8% | 20.2% | 19.5% | 19.5% |
| 50–65% | 16.6% | 16.6% | 25.7% | 22.7% | 22.6% |
| 65–80% | 14.1% | 14.1% | 17.8% | 20.1% | 20.0% |
| 80–90% | 9.5% | 9.5% | 4.5% | 3.6% | 3.6% |
| 90–100% | 11.0% | 11.0% | 9.0% | 10.4% | 10.4% |
| Unknown | 2.8% | 2.8% | 2.2% | 4.2% | 4.2% |
| District mean ACT score | | | | | |
| <16.50 | | 9.9% | 9.9% | 9.2% | 9.2% |
| 16.50–17.41 | | 10.0% | 10.0% | 9.5% | 9.4% |
| 17.41–17.73 | | 10.1% | 10.1% | 1.9% | 1.9% |
| 17.73–18.34 | | 10.3% | 10.3% | 7.8% | 7.7% |
| 18.34–18.85 | | 9.6% | 9.6% | 10.5% | 10.5% |
| 18.85–19.30 | | 10.1% | 10.1% | 12.1% | 12.0% |
| 19.30–19.89 | | 10.0% | 10.0% | 6.8% | 6.8% |
| 19.89–20.59 | | 10.0% | 10.0% | 9.4% | 9.4% |
| 20.59–21.83 | | 10.0% | 10.0% | 7.1% | 7.1% |
| >21.83 | | 10.0% | 10.0% | 13.1% | 13.3% |
| Unknown | | | | 12.6% | 12.7% |
| Mean (SD) district mean ACT score | | 18.9 (2.8) | 19.0 (2.2) | 19.2 (2.2) | 19.2 (2.2) |
| Mean (SD) grade 9 ACT Aspire score | | | | 424.7 (8.4) | 424.8 (8.6) |

[a]ACT state and district testing public school sample weighted to national population of U.S. elementary and secondary students on race/ethnicity and school FRL.

To present a clear picture of the weighting variables and their roles, Figure 8.1 summarizes the weighting procedure for the ACT Aspire spring norms.

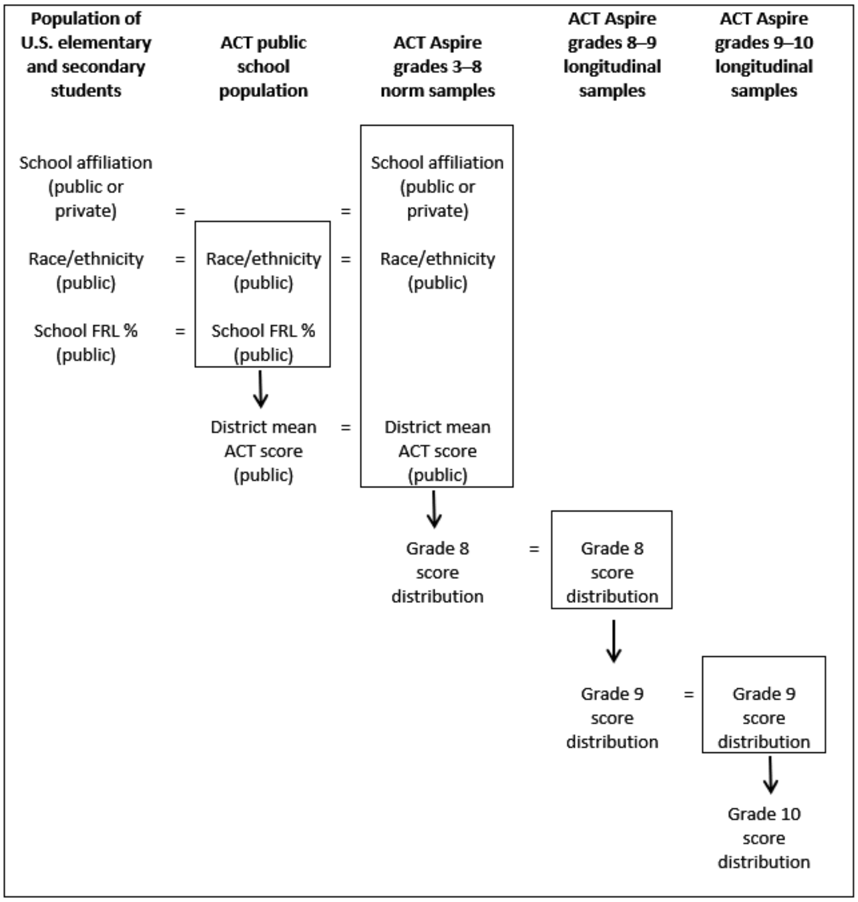


**Figure 8.1. Conceptual diagram of chain-linked weighting strategy.**

*Note*. Variables used for weighting are included in boxes.

# 8.4.2 Fall Norms

ACT Aspire spring norms are based on data from spring testers and used in reporting for both fall and spring administrations. Norms based on data from fall testers are presented to serve as an additional reference to facilitate score interpretation. One thing to note is that the weighting methodology used in generating spring norms was not used to generate the fall norms. Rather, unweighted data from fall testers were used. Below is a description for the samples and norm information for fall norms.

## *8.4.2.1 Sample Descriptions for Fall Norms*

For grades 3–10, the fall norm samples included students who took ACT Aspire on-grade subject tests in fall 2016, fall 2017, or fall 2018, which is consistent with the goal of including the most recent three years of data for ACT Aspire norms. Table 8.27 provides the sample sizes by grade and subject.

**Table 8.27. Sample Sizes Used for Fall Norm Establishment**

| | Subject/Reported Score | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | Composite | ELA | STEM |
| 3 | 8,157 | 8,424 | 8,338 | 7,954 | 7,824 | 5,124 | 7,934 |
| 4 | 19,475 | 20,000 | 19,931 | 19,147 | 18,934 | 5,424 | 19,113 |
| 5 | 17,222 | 18,044 | 17,930 | 17,041 | 16,777 | 6,696 | 16,972 |
| 6 | 30,600 | 31,249 | 31,155 | 30,080 | 29,750 | 12,025 | 29,954 |
| 7 | 41,986 | 45,762 | 45,685 | 42,035 | 40,895 | 23,891 | 41,832 |
| 8 | 93,325 | 97,888 | 98,025 | 93,521 | 90,236 | 61,609 | 92,468 |
| 9 | 82,003 | 83,511 | 82,647 | 80,668 | 78,035 | 52,538 | 80,194 |
| 10 | 81,974 | 83,335 | 83,070 | 80,858 | 78,173 | 66,024 | 80,207 |

## *8.4.2.2 Fall Norm Tables and Related Statistics*

The fall norm tables include the cumulative percentages of students scoring at or below each scale score in the unweighted norm sample from fall testers. The fall norm tables are presented in Tables 8.28–8.34. The mean scale score values for students in each grade and subject test are given in Table 8.35. Finally, Table 8.36 shows the percentage of students meeting ACT Readiness Benchmark in each grade and subject test.

**Table 8.28. English Fall Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 7 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| 408 | 11 | 4 | 2 | 1 | 2 | 2 | 2 | 1 |
| 409 | 16 | 6 | 3 | 2 | 2 | 3 | 3 | 2 |
| 410 | 23 | 9 | 4 | 2 | 3 | 4 | 4 | 3 |
| 411 | 29 | 11 | 5 | 4 | 4 | 5 | 5 | 3 |
| 412 | 35 | 15 | 7 | 6 | 5 | 6 | 6 | 4 |
| 413 | 41 | 19 | 10 | 8 | 7 | 8 | 7 | 6 |
| 414 | 48 | 22 | 12 | 10 | 9 | 9 | 9 | 8 |
| 415 | 55 | 27 | 16 | 13 | 10 | 10 | 12 | 10 |
| 416 | 60 | 32 | 20 | 16 | 12 | 12 | 13 | 11 |
| 417 | 65 | 38 | 24 | 20 | 14 | 15 | 16 | 14 |
| 418 | 71 | 44 | 29 | 25 | 16 | 17 | 18 | 16 |
| 419 | 76 | 51 | 34 | 28 | 18 | 20 | 21 | 19 |
| 420 | 80 | 55 | 40 | 31 | 22 | 21 | 23 | 21 |
| 421 | 84 | 61 | 46 | 35 | 25 | 26 | 26 | 23 |
| 422 | 88 | 65 | 48 | 40 | 27 | 29 | 29 | 26 |
| 423 | 90 | 71 | 54 | 45 | 32 | 32 | 32 | 28 |
| 424 | 92 | 76 | 60 | 50 | 37 | 36 | 35 | 31 |
| 425 | 94 | 81 | 66 | 54 | 40 | 40 | 38 | 34 |
| 426 | 96 | 84 | 71 | 57 | 45 | 44 | 42 | 38 |
| 427 | 97 | 87 | 74 | 62 | 50 | 47 | 45 | 41 |
| 428 | 98 | 91 | 79 | 67 | 53 | 53 | 49 | 44 |
| 429 | 99 | 94 | 84 | 72 | 57 | 57 | 53 | 48 |
| 430 | 99 | 95 | 87 | 76 | 62 | 62 | 56 | 51 |

**Table 8.28. English Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 97 | 90 | 80 | 67 | 67 | 60 | 55 |
| 432 | 99 | 98 | 92 | 84 | 72 | 72 | 64 | 59 |
| 433 | 99 | 99 | 94 | 85 | 75 | 74 | 67 | 62 |
| 434 | 99 | 99 | 96 | 88 | 80 | 77 | 71 | 66 |
| 435 | 100 | 99 | 97 | 90 | 84 | 79 | 74 | 69 |
| 436 | | 99 | 98 | 92 | 87 | 83 | 77 | 72 |
| 437 | | 99 | 98 | 93 | 89 | 87 | 80 | 75 |
| 438 | | 100 | 99 | 95 | 91 | 88 | 82 | 77 |
| 439 | | | 99 | 96 | 94 | 91 | 84 | 80 |
| 440 | | | 99 | 97 | 94 | 93 | 86 | 82 |
| 441 | | | 99 | 98 | 96 | 94 | 88 | 84 |
| 442 | | | 100 | 99 | 97 | 95 | 90 | 86 |
| 443 | | | | 99 | 98 | 97 | 92 | 89 |
| 444 | | | | 99 | 99 | 97 | 94 | 91 |
| 445 | | | | 99 | 99 | 98 | 96 | 93 |
| 446 | | | | 99 | 99 | 99 | 97 | 95 |
| 447 | | | | 99 | 99 | 99 | 97 | 95 |
| 448 | | | | 100 | 99 | 99 | 98 | 97 |
| 449 | | | | | 99 | 99 | 99 | 98 |
| 450 | | | | | 100 | 99 | 99 | 98 |
| 451 | | | | | | 99 | 99 | 99 |
| 452 | | | | | | 100 | 99 | 99 |
| 453 | | | | | | | 99 | 99 |
| 454 | | | | | | | 99 | 99 |
| 455 | | | | | | | 99 | 99 |
| 456 | | | | | | | 100 | 100 |

Table 8.29. Mathematics Fall Norms: Percentage of Students at or below Each Scale Score

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 14 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 20 | 3 | 2 | 1 | 2 | 1 | 1 | 1 |
| 408 | 26 | 5 | 4 | 2 | 4 | 2 | 1 | 1 |
| 409 | 35 | 7 | 6 | 2 | 5 | 3 | 2 | 2 |
| 410 | 43 | 12 | 10 | 4 | 6 | 5 | 3 | 3 |
| 411 | 52 | 19 | 14 | 6 | 9 | 7 | 4 | 4 |
| 412 | 62 | 26 | 19 | 8 | 11 | 9 | 5 | 5 |
| 413 | 72 | 37 | 26 | 12 | 14 | 11 | 7 | 7 |
| 414 | 81 | 48 | 32 | 17 | 19 | 15 | 10 | 9 |
| 415 | 88 | 56 | 42 | 23 | 23 | 19 | 13 | 11 |
| 416 | 93 | 66 | 50 | 30 | 29 | 24 | 16 | 14 |
| 417 | 96 | 73 | 60 | 35 | 36 | 28 | 20 | 18 |
| 418 | 98 | 80 | 66 | 43 | 40 | 33 | 25 | 22 |
| 419 | 99 | 86 | 75 | 50 | 46 | 38 | 28 | 25 |
| 420 | 99 | 90 | 80 | 57 | 52 | 42 | 32 | 28 |
| 421 | 99 | 93 | 85 | 62 | 56 | 47 | 37 | 33 |
| 422 | 99 | 96 | 89 | 69 | 60 | 52 | 40 | 36 |
| 423 | 99 | 98 | 91 | 74 | 65 | 56 | 45 | 41 |
| 424 | 99 | 99 | 93 | 80 | 70 | 60 | 48 | 44 |
| 425 | 99 | 99 | 94 | 84 | 74 | 65 | 52 | 48 |
| 426 | 99 | 99 | 96 | 87 | 78 | 69 | 56 | 51 |
| 427 | 99 | 99 | 97 | 90 | 81 | 72 | 61 | 56 |
| 428 | 99 | 99 | 98 | 92 | 83 | 75 | 64 | 59 |
| 429 | 99 | 99 | 98 | 94 | 85 | 78 | 67 | 61 |
| 430 | 99 | 99 | 99 | 96 | 88 | 80 | 70 | 65 |

Table 8.29. Mathematics Fall Norms: Percentage of Students at or below Each Scale Score—continued

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 99 | 97 | 90 | 83 | 74 | 69 |
| 432 | 99 | 99 | 99 | 98 | 92 | 85 | 76 | 72 |
| 433 | 99 | 99 | 99 | 98 | 94 | 87 | 79 | 74 |
| 434 | 100 | 99 | 99 | 99 | 95 | 89 | 82 | 78 |
| 435 | | 99 | 99 | 99 | 96 | 90 | 85 | 81 |
| 436 | | 99 | 99 | 99 | 97 | 92 | 87 | 83 |
| 437 | | 99 | 99 | 99 | 98 | 94 | 89 | 86 |
| 438 | | 99 | 99 | 99 | 99 | 95 | 91 | 89 |
| 439 | | 99 | 99 | 99 | 99 | 96 | 92 | 90 |
| 440 | | 100 | 99 | 99 | 99 | 97 | 94 | 93 |
| 441 | | | 99 | 99 | 99 | 98 | 95 | 95 |
| 442 | | | 99 | 99 | 99 | 99 | 97 | 97 |
| 443 | | | 99 | 99 | 99 | 99 | 98 | 98 |
| 444 | | | 99 | 99 | 99 | 99 | 99 | 99 |
| 445 | | | 99 | 99 | 99 | 99 | 99 | 99 |
| 446 | | | 100 | 99 | 99 | 99 | 99 | 99 |
| 447 | | | | 99 | 99 | 99 | 99 | 99 |
| 448 | | | | 99 | 99 | 99 | 99 | 99 |
| 449 | | | | 99 | 99 | 99 | 99 | 99 |
| 450 | | | | 99 | 99 | 99 | 99 | 99 |
| 451 | | | | 100 | 99 | 99 | 99 | 99 |
| 452 | | | | | 99 | 99 | 99 | 99 |
| 453 | | | | | 100 | 99 | 99 | 99 |
| 454 | | | | | | 99 | 99 | 99 |
| 455 | | | | | | 99 | 99 | 99 |
| 456 | | | | | | 100 | 99 | 99 |
| 457 | | | | | | | 99 | 99 |
| 458 | | | | | | | 99 | 99 |
| 459 | | | | | | | 99 | 99 |
| 460 | | | | | | | 100 | 100 |

**Table 8.30. Reading Fall Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 |
| 405 | 11 | 5 | 2 | 1 | 1 | 1 | 1 | 1 |
| 406 | 17 | 9 | 4 | 3 | 1 | 2 | 1 | 1 |
| 407 | 29 | 11 | 6 | 5 | 3 | 3 | 2 | 2 |
| 408 | 36 | 16 | 10 | 8 | 4 | 4 | 3 | 3 |
| 409 | 43 | 20 | 13 | 11 | 7 | 5 | 5 | 4 |
| 410 | 50 | 26 | 18 | 14 | 10 | 8 | 8 | 6 |
| 411 | 57 | 31 | 22 | 17 | 13 | 10 | 11 | 9 |
| 412 | 62 | 36 | 27 | 22 | 16 | 13 | 13 | 11 |
| 413 | 67 | 41 | 32 | 25 | 20 | 16 | 16 | 13 |
| 414 | 73 | 50 | 38 | 30 | 24 | 19 | 19 | 16 |
| 415 | 79 | 53 | 44 | 35 | 27 | 21 | 22 | 19 |
| 416 | 83 | 58 | 49 | 39 | 31 | 25 | 25 | 22 |
| 417 | 87 | 64 | 55 | 43 | 35 | 28 | 29 | 26 |
| 418 | 90 | 70 | 61 | 49 | 40 | 31 | 33 | 28 |
| 419 | 94 | 75 | 65 | 54 | 45 | 35 | 36 | 31 |
| 420 | 96 | 80 | 71 | 57 | 50 | 38 | 41 | 35 |
| 421 | 97 | 85 | 75 | 62 | 55 | 43 | 45 | 39 |
| 422 | 99 | 89 | 79 | 67 | 60 | 47 | 48 | 42 |
| 423 | 99 | 91 | 84 | 73 | 66 | 52 | 53 | 47 |
| 424 | 99 | 93 | 86 | 76 | 71 | 57 | 57 | 52 |
| 425 | 99 | 96 | 90 | 80 | 76 | 63 | 60 | 55 |
| 426 | 99 | 97 | 93 | 84 | 81 | 68 | 65 | 60 |
| 427 | 99 | 98 | 95 | 89 | 86 | 73 | 68 | 63 |
| 428 | 99 | 99 | 97 | 92 | 91 | 78 | 72 | 67 |
| 429 | 100 | 99 | 98 | 96 | 93 | 83 | 76 | 72 |
| 430 | | 99 | 99 | 96 | 95 | 86 | 80 | 77 |

**Table 8.30. Reading Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | | 100 | 99 | 98 | 97 | 89 | 84 | 80 |
| 432 | | | 99 | 99 | 99 | 93 | 88 | 85 |
| 433 | | | 99 | 99 | 99 | 96 | 92 | 90 |
| 434 | | | 100 | 99 | 99 | 98 | 94 | 93 |
| 435 | | | | 99 | 99 | 98 | 97 | 96 |
| 436 | | | | 100 | 99 | 99 | 99 | 98 |
| 437 | | | | | 99 | 99 | 99 | 99 |
| 438 | | | | | 100 | 99 | 99 | 99 |
| 439 | | | | | | 99 | 99 | 99 |
| 440 | | | | | | 100 | 99 | 99 |
| 441 | | | | | | | 99 | 99 |
| 442 | | | | | | | 100 | 100 |

**Table 8.31. Science Fall Norms: Percentage of Students at or below Each Scale Score**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 7 | 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 10 | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 15 | 6 | 2 | 2 | 2 | 2 | 1 | 1 |
| 407 | 21 | 9 | 3 | 3 | 3 | 2 | 1 | 1 |
| 408 | 29 | 13 | 6 | 5 | 4 | 4 | 2 | 2 |
| 409 | 35 | 15 | 8 | 7 | 7 | 6 | 3 | 2 |
| 410 | 40 | 19 | 12 | 10 | 9 | 8 | 4 | 3 |
| 411 | 45 | 24 | 15 | 13 | 12 | 10 | 6 | 5 |
| 412 | 53 | 28 | 18 | 16 | 15 | 13 | 7 | 6 |
| 413 | 58 | 32 | 22 | 20 | 18 | 17 | 10 | 8 |
| 414 | 63 | 37 | 26 | 23 | 19 | 18 | 12 | 9 |
| 415 | 67 | 42 | 30 | 27 | 22 | 21 | 16 | 13 |
| 416 | 71 | 47 | 35 | 30 | 26 | 25 | 19 | 16 |
| 417 | 75 | 52 | 40 | 33 | 31 | 28 | 23 | 19 |
| 418 | 78 | 58 | 45 | 37 | 35 | 32 | 27 | 23 |
| 419 | 82 | 62 | 51 | 40 | 38 | 35 | 31 | 26 |
| 420 | 85 | 67 | 57 | 44 | 42 | 39 | 34 | 29 |
| 421 | 89 | 71 | 62 | 50 | 45 | 42 | 38 | 33 |
| 422 | 92 | 78 | 66 | 55 | 49 | 46 | 41 | 37 |
| 423 | 94 | 82 | 72 | 59 | 54 | 50 | 45 | 40 |
| 424 | 96 | 85 | 77 | 65 | 57 | 55 | 50 | 44 |
| 425 | 98 | 89 | 80 | 70 | 61 | 59 | 54 | 48 |
| 426 | 99 | 92 | 85 | 76 | 65 | 62 | 58 | 52 |
| 427 | 99 | 94 | 89 | 81 | 70 | 66 | 61 | 55 |
| 428 | 99 | 95 | 92 | 85 | 74 | 71 | 64 | 58 |
| 429 | 99 | 97 | 94 | 88 | 78 | 74 | 68 | 62 |
| 430 | 99 | 98 | 96 | 90 | 81 | 78 | 71 | 65 |

**Table 8.31. Science Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 97 | 92 | 85 | 82 | 74 | 69 |
| 432 | 99 | 99 | 99 | 95 | 88 | 85 | 77 | 72 |
| 433 | 100 | 99 | 99 | 97 | 91 | 87 | 80 | 75 |
| 434 | | 99 | 99 | 98 | 95 | 90 | 83 | 77 |
| 435 | | 99 | 99 | 99 | 97 | 92 | 86 | 80 |
| 436 | | 100 | 99 | 99 | 98 | 94 | 88 | 83 |
| 437 | | | 99 | 99 | 99 | 95 | 90 | 87 |
| 438 | | | 100 | 99 | 99 | 97 | 93 | 90 |
| 439 | | | | 99 | 99 | 98 | 95 | 93 |
| 440 | | | | 100 | 99 | 99 | 96 | 95 |
| 441 | | | | | 99 | 99 | 97 | 97 |
| 442 | | | | | 99 | 99 | 98 | 98 |
| 443 | | | | | 100 | 99 | 99 | 98 |
| 444 | | | | | | 99 | 99 | 99 |
| 445 | | | | | | 99 | 99 | 99 |
| 446 | | | | | | 100 | 99 | 99 |
| 447 | | | | | | | 99 | 99 |
| 448 | | | | | | | 99 | 99 |
| 449 | | | | | | | 100 | 100 |

**Table 8.32. Composite Score Fall Norms: Percentage of Students at or below Each Scale Score–**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 14 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 22 | 5 | 2 | 1 | 1 | 1 | 1 | 1 |
| 409 | 29 | 9 | 3 | 2 | 2 | 1 | 1 | 1 |
| 410 | 37 | 13 | 6 | 3 | 3 | 2 | 1 | 1 |
| 411 | 45 | 18 | 10 | 6 | 5 | 4 | 2 | 2 |
| 412 | 53 | 24 | 14 | 9 | 8 | 6 | 4 | 3 |
| 413 | 59 | 30 | 18 | 13 | 10 | 8 | 6 | 5 |
| 414 | 66 | 36 | 24 | 17 | 13 | 11 | 9 | 7 |
| 415 | 73 | 42 | 29 | 21 | 17 | 14 | 12 | 9 |
| 416 | 78 | 49 | 35 | 26 | 21 | 18 | 15 | 12 |
| 417 | 83 | 55 | 42 | 31 | 25 | 21 | 19 | 15 |
| 418 | 87 | 62 | 48 | 36 | 29 | 25 | 22 | 18 |
| 419 | 91 | 68 | 55 | 41 | 34 | 29 | 26 | 22 |
| 420 | 94 | 74 | 61 | 46 | 39 | 33 | 30 | 25 |
| 421 | 96 | 80 | 67 | 52 | 44 | 38 | 34 | 29 |
| 422 | 98 | 85 | 73 | 57 | 48 | 42 | 38 | 33 |
| 423 | 99 | 89 | 78 | 63 | 53 | 47 | 42 | 37 |
| 424 | 99 | 92 | 83 | 68 | 58 | 51 | 46 | 41 |
| 425 | 99 | 95 | 87 | 74 | 63 | 56 | 50 | 45 |
| 426 | 99 | 97 | 91 | 79 | 68 | 61 | 54 | 49 |
| 427 | 99 | 98 | 93 | 83 | 73 | 66 | 59 | 53 |
| 428 | 99 | 99 | 96 | 87 | 77 | 70 | 63 | 57 |
| 429 | 99 | 99 | 97 | 90 | 81 | 74 | 67 | 61 |
| 430 | 99 | 99 | 98 | 93 | 85 | 78 | 71 | 65 |

**Table 8.32. Composite Score Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 99 | 95 | 88 | 82 | 74 | 69 |
| 432 | 99 | 99 | 99 | 97 | 92 | 85 | 78 | 72 |
| 433 | 100 | 99 | 99 | 98 | 94 | 88 | 81 | 76 |
| 434 | | 99 | 99 | 99 | 96 | 90 | 84 | 80 |
| 435 | | 99 | 99 | 99 | 97 | 93 | 87 | 83 |
| 436 | | 100 | 99 | 99 | 99 | 95 | 90 | 86 |
| 437 | | | 99 | 99 | 99 | 96 | 92 | 89 |
| 438 | | | 99 | 99 | 99 | 97 | 94 | 92 |
| 439 | | | 99 | 99 | 99 | 98 | 96 | 94 |
| 440 | | | 100 | 99 | 99 | 99 | 97 | 96 |
| 441 | | | | 99 | 99 | 99 | 98 | 97 |
| 442 | | | | 99 | 99 | 99 | 99 | 98 |
| 443 | | | | 99 | 99 | 99 | 99 | 99 |
| 444 | | | | 100 | 99 | 99 | 99 | 99 |
| 445 | | | | | 99 | 99 | 99 | 99 |
| 446 | | | | | 100 | 99 | 99 | 99 |
| 447 | | | | | | 99 | 99 | 99 |
| 448 | | | | | | 99 | 99 | 99 |
| 449 | | | | | | 100 | 99 | 99 |
| 450 | | | | | | | 99 | 99 |
| 451 | | | | | | | 99 | 99 |
| 452 | | | | | | | 100 | 100 |

Table 8.33. ELA Score Fall Norms: Percentage of Students at or below Each Scale Score

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 409 | 8 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 410 | 13 | 3 | 2 | 1 | 2 | 2 | 2 | 1 |
| 411 | 19 | 6 | 4 | 2 | 3 | 3 | 3 | 2 |
| 412 | 26 | 10 | 6 | 4 | 5 | 5 | 5 | 3 |
| 413 | 33 | 14 | 9 | 5 | 7 | 6 | 7 | 5 |
| 414 | 41 | 19 | 12 | 8 | 9 | 8 | 9 | 7 |
| 415 | 49 | 25 | 17 | 10 | 12 | 11 | 11 | 9 |
| 416 | 57 | 32 | 22 | 14 | 15 | 13 | 14 | 11 |
| 417 | 65 | 38 | 28 | 17 | 18 | 16 | 17 | 14 |
| 418 | 72 | 46 | 34 | 22 | 22 | 20 | 20 | 17 |
| 419 | 79 | 55 | 40 | 27 | 26 | 23 | 24 | 21 |
| 420 | 84 | 63 | 47 | 32 | 31 | 28 | 28 | 24 |
| 421 | 89 | 70 | 55 | 38 | 36 | 32 | 32 | 28 |
| 422 | 93 | 76 | 62 | 44 | 42 | 37 | 36 | 32 |
| 423 | 95 | 81 | 68 | 50 | 48 | 42 | 40 | 37 |
| 424 | 97 | 87 | 75 | 57 | 54 | 48 | 45 | 41 |
| 425 | 98 | 91 | 80 | 63 | 59 | 54 | 50 | 46 |
| 426 | 99 | 95 | 85 | 69 | 65 | 59 | 54 | 50 |
| 427 | 99 | 97 | 89 | 75 | 71 | 65 | 59 | 55 |
| 428 | 99 | 98 | 92 | 80 | 77 | 71 | 64 | 60 |
| 429 | 99 | 99 | 94 | 85 | 82 | 76 | 69 | 65 |
| 430 | 99 | 99 | 96 | 89 | 86 | 81 | 73 | 69 |

**Table 8.33. ELA Score Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 98 | 92 | 90 | 85 | 78 | 74 |
| 432 | 99 | 99 | 99 | 95 | 93 | 89 | 82 | 78 |
| 433 | 99 | 99 | 99 | 96 | 95 | 92 | 86 | 82 |
| 434 | 99 | 99 | 99 | 98 | 97 | 94 | 89 | 86 |
| 435 | 100 | 99 | 99 | 99 | 98 | 96 | 92 | 89 |
| 436 | | 100 | 99 | 99 | 99 | 98 | 95 | 92 |
| 437 | | | 99 | 99 | 99 | 99 | 96 | 95 |
| 438 | | | 99 | 99 | 99 | 99 | 98 | 97 |
| 439 | | | 100 | 99 | 99 | 99 | 99 | 98 |
| 440 | | | | 99 | 99 | 99 | 99 | 99 |
| 441 | | | | 99 | 99 | 99 | 99 | 99 |
| 442 | | | | 99 | 99 | 99 | 99 | 99 |
| 443 | | | | 99 | 99 | 99 | 99 | 99 |
| 444 | | | | 100 | 99 | 99 | 99 | 99 |
| 445 | | | | | 100 | 99 | 99 | 99 |
| 446 | | | | | | 99 | 99 | 99 |
| 447 | | | | | | 100 | 99 | 99 |
| 448 | | | | | | | 99 | 99 |
| 449 | | | | | | | 100 | 100 |

Table 8.34. STEM Score Fall Norms: Percentage of Students at or below Each Scale Score

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 400 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 401 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 402 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 403 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 404 | 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 405 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 406 | 12 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 407 | 18 | 3 | 1 | 1 | 1 | 1 | 1 | 1 |
| 408 | 25 | 6 | 2 | 1 | 2 | 1 | 1 | 1 |
| 409 | 32 | 10 | 5 | 2 | 3 | 2 | 1 | 1 |
| 410 | 40 | 14 | 8 | 4 | 5 | 4 | 2 | 1 |
| 411 | 48 | 20 | 11 | 7 | 8 | 6 | 3 | 2 |
| 412 | 55 | 26 | 16 | 10 | 10 | 8 | 4 | 3 |
| 413 | 62 | 32 | 21 | 14 | 14 | 11 | 6 | 5 |
| 414 | 69 | 39 | 26 | 18 | 17 | 15 | 9 | 7 |
| 415 | 74 | 46 | 32 | 23 | 21 | 18 | 12 | 10 |
| 416 | 80 | 53 | 39 | 28 | 26 | 22 | 15 | 13 |
| 417 | 85 | 59 | 47 | 33 | 30 | 26 | 19 | 16 |
| 418 | 89 | 66 | 53 | 38 | 35 | 30 | 23 | 20 |
| 419 | 93 | 72 | 61 | 43 | 40 | 35 | 27 | 23 |
| 420 | 96 | 78 | 67 | 49 | 45 | 39 | 31 | 27 |
| 421 | 98 | 84 | 73 | 55 | 49 | 43 | 35 | 31 |
| 422 | 99 | 88 | 78 | 61 | 54 | 48 | 40 | 35 |
| 423 | 99 | 91 | 83 | 67 | 58 | 52 | 44 | 39 |
| 424 | 99 | 94 | 87 | 73 | 63 | 57 | 48 | 43 |
| 425 | 99 | 96 | 90 | 78 | 67 | 61 | 52 | 46 |
| 426 | 99 | 98 | 93 | 82 | 71 | 65 | 56 | 50 |
| 427 | 99 | 99 | 95 | 86 | 75 | 69 | 60 | 54 |
| 428 | 99 | 99 | 96 | 90 | 79 | 73 | 64 | 58 |
| 429 | 99 | 99 | 98 | 92 | 83 | 77 | 68 | 62 |
| 430 | 99 | 99 | 98 | 94 | 86 | 80 | 71 | 65 |

**Table 8.34. STEM Score Fall Norms: Percentage of Students at or below Each Scale Score—continued**

| | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Scale Score | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 431 | 99 | 99 | 99 | 96 | 88 | 83 | 74 | 69 |
| 432 | 99 | 99 | 99 | 97 | 91 | 85 | 77 | 72 |
| 433 | 99 | 99 | 99 | 98 | 93 | 88 | 80 | 75 |
| 434 | 100 | 99 | 99 | 99 | 95 | 90 | 83 | 78 |
| 435 | | 99 | 99 | 99 | 97 | 92 | 86 | 82 |
| 436 | | 99 | 99 | 99 | 98 | 93 | 88 | 85 |
| 437 | | 99 | 99 | 99 | 99 | 95 | 90 | 87 |
| 438 | | 100 | 99 | 99 | 99 | 96 | 92 | 90 |
| 439 | | | 99 | 99 | 99 | 97 | 94 | 92 |
| 440 | | | 99 | 99 | 99 | 98 | 96 | 94 |
| 441 | | | 99 | 99 | 99 | 99 | 97 | 96 |
| 442 | | | 100 | 99 | 99 | 99 | 98 | 97 |
| 443 | | | | 99 | 99 | 99 | 99 | 98 |
| 444 | | | | 99 | 99 | 99 | 99 | 99 |
| 445 | | | | 99 | 99 | 99 | 99 | 99 |
| 446 | | | | 100 | 99 | 99 | 99 | 99 |
| 447 | | | | | 99 | 99 | 99 | 99 |
| 448 | | | | | 100 | 99 | 99 | 99 |
| 449 | | | | | | 99 | 99 | 99 |
| 450 | | | | | | 99 | 99 | 99 |
| 451 | | | | | | 100 | 99 | 99 |
| 452 | | | | | | | 99 | 99 |
| 453 | | | | | | | 99 | 99 |
| 454 | | | | | | | 99 | 99 |
| 455 | | | | | | | 100 | 100 |

**Table 8.35. National Average Scale Scores Based on Fall Norm Samples**

| | Subject/Reported Score | | | | | | |
|---|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | Composite | ELA | STEM |
| 3 | 415 | 411 | 411 | 413 | 413 | 416 | 412 |
| 4 | 420 | 415 | 415 | 417 | 417 | 419 | 416 |
| 5 | 423 | 417 | 417 | 419 | 419 | 421 | 418 |
| 6 | 425 | 420 | 419 | 421 | 421 | 423 | 421 |
| 7 | 427 | 421 | 420 | 422 | 423 | 424 | 422 |
| 8 | 427 | 423 | 422 | 423 | 424 | 424 | 423 |
| 9 | 429 | 426 | 423 | 425 | 426 | 425 | 426 |
| 10 | 430 | 427 | 424 | 426 | 427 | 426 | 427 |

**Table 8.36. Percentage of Students Who Met Benchmark in Fall Norm Samples**

| | Subject/Reported Score | | | | | |
|---|---|---|---|---|---|---|
| Grade | English | Mathematics | Reading | Science | ELA | STEM |
| 3 | 65 | 38 | 27 | 25 | 28 | 7 |
| 4 | 68 | 44 | 42 | 38 | 30 | 16 |
| 5 | 71 | 40 | 35 | 38 | 32 | 13 |
| 6 | 72 | 50 | 43 | 45 | 37 | 14 |
| 7 | 78 | 44 | 40 | 43 | 41 | 17 |
| 8 | 74 | 40 | 48 | 38 | 41 | 15 |
| 9 | 62 | 39 | 43 | 32 | 41 | 17 |
| 10 | 59 | 31 | 37 | 31 | 35 | 15 |

*Note*. Benchmark is not available for ACT Aspire Composite score.

# 8.5 ACT Aspire Reporting

The ACT Aspire Summative Assessments is a longitudinal assessment system designed to measure student growth through a vertical score scale. ACT Aspire scale scores are linked to college and career readiness through scores on the ACT and the ACT WorkKeys National Career Readiness Certificate program.

The objectives of ACT Aspire Summative Assessment reporting are as follows.

- To clearly communicate what College and Career Readiness means and whether a student is on track to achieve it
- To clearly communicate strengths and opportunity areas early on in a child's educational career to enable greater personal academic and career success
- To include additional measures that provide a more complete picture of a student's academic and personal achievement
- To clearly communicate each student's personal path to improvement and provide actionable next steps
- To connect teaching and learning by providing educators with reports on each student's specific skills
- To provide educators at all levels with the insights needed to improve student performance
- To use technology to make the user experience faster and more effective by including deeper, richer insights and more valuable data than what is traditionally provided with paper reports
- To use technology to make results available across various platforms including computers and tablets

The ACT Aspire administration platform serves as the delivery engine for test results. Individual student reports, a student performance file, and several aggregate reports are posted in the platform after scoring is completed. Interpretive materials are available to help parents, teachers, and students better understand what is needed for continual academic growth.

# References

Wang, M. W., & Stanley, J. C. (1970). Differential weighting: A review of methods and empirical studies. *Review of Educational Research, 40*(5), 663–705.

Chapter 9

# ACT Readiness Benchmarks and Progress Toward Career Readiness

## 9.1 Overview

This chapter summarizes the development and interpretation of various indicators of college and career readiness linked to ACT Aspire scores. Specifically, the chapter describes the following:

- ACT Readiness Benchmarks, indicating whether students are on track to meet the ACT College Readiness Benchmarks in grade 11
- ACT Readiness Levels, providing finer distinctions of student performance relative to the ACT Readiness Benchmarks
- Readiness ranges for reporting category scores
- The Progress Toward Career Readiness indicator that predicts future achievement on the ACT National Career Readiness Certificate® (ACT NCRC®)

## 9.2 ACT Readiness Benchmarks, Levels, and Ranges

The ACT College Readiness Benchmarks were established to reflect the minimum scores students need to be college ready and are defined as the ACT scores associated with a 50% chance of attaining a grade of B or higher or approximately a 75% chance of obtaining a C or higher in selected first-year credit-bearing college courses (Allen, 2013; Radunzel, Westrick, Bassiri, & Li, 2017).

This section mainly presents the method and procedures used to set the ACT Readiness Benchmarks for ACT Aspire assessments. The ACT Readiness Benchmarks were created to align with the ACT College Readiness Benchmarks as well as Benchmarks used for the legacy ACT Explore (grade 8 and 9) and ACT Plan (grade 10) programs. Collectively, the ACT Explore, ACT Plan, and the ACT formed a longitudinal assessment system known as EPAS. The ACT Explore and ACT Plan assessments were retired in 2014. Similar to the EPAS Benchmarks, for ACT Aspire, by subject separate ACT Readiness Benchmarks were developed for each grade. Students at or above the Benchmarks are on target to meet the corresponding ACT College Readiness Benchmarks in grade 11. Later, this section provides the methods to set the ACT Readiness Levels and Ranges.

## 9.2.1 ACT Readiness Benchmarks for English, Mathematics, Reading, and Science

For English, mathematics, reading, and science, the ACT Readiness Benchmarks for grades 8 through 10 were derived from the EPAS to ACT Aspire concordance tables. The corresponding concorded ACT Aspire scale scores for the EPAS Benchmarks were adopted as the ACT Readiness Benchmarks on the ACT Aspire scale. The grade 8 ACT Readiness Benchmarks were then used to obtain the ACT Readiness Benchmarks for grades 3–7 using a *z*-score backmapping procedure.

### *9.2.1.1 Grades 8–10*

A concordance between the EPAS 1–36 scale and the ACT Aspire three-digit scale was used to establish ACT Readiness Benchmarks for grades 8–10 based on the Benchmarks that had already been established for EPAS. The concordance study included students taking both the EPAS and ACT Aspire tests. The concordance between EPAS scale scores and ACT Aspire scale scores was obtained using an equipercentile linking procedure. The EPAS Benchmarks for grades 8, 9, and 10 were used to identify comparable ACT Aspire scores, which were then defined as the ACT Readiness Benchmarks for grades 8–10. Note that the concorded Benchmarks derived for grades 8–10 may be updated if necessary as these Benchmarks continue to be monitored. Also note that since the original EPAS/ACT Aspire Concordance, concordances between ACT Aspire and PreACT/ACT scores have been developed (see Appendix G). However, the Benchmarks are based on the original EPAS/ACT Aspire Concordance.

The EPAS Benchmarks used in this analysis were obtained by using an alternate set of benchmarks instead of those that were typically reported for ACT Explore and ACT Plan. This alternate set of benchmarks was based on students tested in spring while EPAS Benchmarks typically used for grades 8–10 were based on students tested in fall. ACT Aspire is administered in both fall and spring, and it is expected that benchmarks would differ slightly within the same grade due to additional academic growth that occurs from fall to spring. Spring benchmarks were used because they anchored the ACT Readiness Benchmarks to spring levels of educational development, near the end of a particular grade when ACT Aspire was anticipated to be most commonly administered. Therefore, the ACT Readiness Benchmarks used for ACT Aspire are based on students tested in spring and reflect performance levels of students toward the end of an academic year. This should be kept in mind when interpreting results from the fall testing.

Table 9.1 presents the spring-referenced EPAS Benchmarks on the 1–36 scale for grades 8, 9, and 10 used in this study and the corresponding ACT Readiness Benchmarks, which are the comparable ACT Aspire scores obtained from the concordance. A single set of ACT Readiness Benchmarks is applied across all test forms and testing models.

**Table 9.1. EPAS College Readiness Benchmarks and ACT Readiness Benchmarks for English, Mathematics, Reading, and Science for Grades 8–10**

| Subject | Grade | EPAS College Readiness Benchmark (Spring) | ACT Readiness Benchmark (Concorded ACT Aspire Score) |
|---|---|---|---|
| English | 8 | 13 | 422 |
| | 9 | 15 | 426 |
| | 10 | 16 | 428 |
| Mathematics | 8 | 17 | 425 |
| | 9 | 18 | 428 |
| | 10 | 20 | 432 |
| Reading | 8 | 17 | 424 |
| | 9 | 18 | 425 |
| | 10 | 20 | 428 |
| Science | 8 | 19 | 427 |
| | 9 | 20 | 430 |
| | 10 | 21 | 432 |

To evaluate the ACT Readiness Benchmarks, agreement rates for classifying students at or above both sets of benchmarks were compared using data from the concordance study. There was agreement if students were classified into the same category using both the EPAS Benchmarks and the ACT Readiness Benchmarks of their particular grade. As shown in Table 9.2, the agreement rates for all subjects were at or above 80%.

**Table 9.2. Classification Agreement Rates Between ACT Aspire and EPAS Benchmarks**

| | ACT Explore | ACT Plan |
|---|---|---|
| English | 81% | 80% |
| Mathematics | 82% | 85% |
| Reading | 81% | 81% |
| Science | 83% | 84% |

### *9.2.1.2 Grades 3–7*

ACT Readiness Benchmarks for grades 3–7 in English, mathematics, reading, and science were backmapped from the grade 8 ACT Readiness Benchmarks described above. Backmapping used a *z*-score approach, which involved identifying the ACT Aspire scores at a standardized score (*z* score) that corresponded to the *z* score for the grade 8 ACT Readiness Benchmark. Specifically, a *z* score

($z_8$) corresponding to the grade 8 ACT Readiness Benchmark was computed based on the difference between this benchmark score ($x$) and the mean (μ) of the grade 8 scale scores and divided by the standard deviation (σ) of the grade 8 scale scores: $z_8 = (x - \mu)/\sigma$. This $z$ score was then used to obtain the ACT Readiness Benchmarks for grades 3–7 ($x_j$) based on the standard deviation ($\sigma_j$) and mean ($\mu_j$) of the scale scores for those grades, respectively, with the formula $x_j = z_8\sigma_j + \mu_j$, where $j$ represents a grade ($j$ = 3, 4, 5, 6, or 7). Data from the special study in spring 2013 were used to set the backmapped ACT Readiness Benchmarks for grades 3–7 as presented in Table 9.3. Note that the backmapped Benchmarks derived for grades 3–7 continue to be reviewed and may be updated if necessary.

**Table 9.3. ACT Readiness Benchmarks for English, Mathematics, Reading, and Science for Grades 3–7**

| Grade | English | Mathematics | Reading | Science |
|---|---|---|---|---|
| 3 | 413 | 413 | 415 | 418 |
| 4 | 417 | 416 | 417 | 420 |
| 5 | 419 | 418 | 420 | 422 |
| 6 | 420 | 420 | 421 | 423 |
| 7 | 421 | 422 | 423 | 425 |

## 9.2.2 ACT Readiness Benchmarks for ELA and STEM

For ACT Aspire, the ACT Readiness Benchmarks for ELA and STEM for grades 3–10 were updated in fall 2017 to better align with the ACT College Readiness Benchmarks for ELA and STEM, after the ELA and STEM Benchmarks on the ACT were published in fall 2017 and fall 2015, respectively. Before fall 2017, the ACT Readiness Benchmarks for ELA and STEM were computed as the average of the Benchmarks from the component tests (e.g., mathematics and science for STEM). This method was used because it was anticipated to be easy to understand and because there were no corresponding ACT College Readiness Benchmarks to backmap from before fall 2017. Full details on the methodology used to update the ELA and STEM Benchmarks are provided in an ACT technical brief (Allen & Fang, 2017), and the updated Benchmarks in Table 9.4 were used for reporting beginning in fall 2017. Below is a summary of the updated ELA and STEM Benchmarks.

- The ELA and STEM Benchmarks for grades 8–10 are the scores associated with a 50% chance of meeting the corresponding ACT College Readiness Benchmarks based on longitudinal data available through spring 2017.
- The Benchmarks for grades 3–7 are approximately the same distance from the mean (in standard deviation units) as the grade 8 Benchmarks. Benchmarks for grades 3–7 are not linked directly to the ACT College Readiness Benchmarks because (1) longitudinal data to the ACT test was not yet available for grades 3–7, and (2) the predictive power is weaker when the grades are further apart.

- The updated STEM Benchmarks are substantially higher than the initial STEM Benchmarks. The STEM Benchmarks for grades 3–10 were initially set as the average of the Benchmarks for mathematics and science but are now linked to the ACT College Readiness Benchmark for the STEM score, which reflects the greater difficulty of the mathematics and science courses taken by students in STEM-related majors.
- The updated ELA and STEM Benchmarks provide greater consistency across grades in the percentage of students meeting the Benchmarks, and they also agree more with average gain scores.
- While two of the components of the ELA score (English and reading scores) are reported on a vertical scale, the writing score component is not. The ELA Benchmark still increases with grade, with the exception of grade 6 to grade 7, where it is 426 for both grades. On average, students' writing scores decrease by about 1.6 score points from grade 6 to grade 7. This contributes to a small average gain in ELA score of about 0.6 points from grade 6 to 7, so having the same integer value of the ELA Benchmark from grade 6 to grade 7 is generally consistent with the small average gain.

**Table 9.4. Updated ELA and STEM Readiness Benchmarks (From Fall 2017)**

| Grade | ELA | STEM |
|---|---|---|
| 3 | 419 | 420 |
| 4 | 422 | 422 |
| 5 | 424 | 425 |
| 6 | 426 | 428 |
| 7 | 426 | 430 |
| 8 | 427 | 433 |
| 9 | 428 | 435 |
| 10 | 430 | 437 |
| 11 (ACT) | 20 | 26 |

Note that it is possible that readiness in ELA or STEM is inconsistent with the readiness in a particular subject. This is due to the compensatory nature of the ELA and STEM scores. For example, a student could be below the mathematics benchmark and still be above the STEM benchmark if the student had a relatively high science test score. In such a case, the science test score could pull her STEM score up enough to meet the STEM Benchmark.

## 9.2.3 ACT Readiness Levels

In addition to the ACT Readiness Benchmarks, students are provided with a finer distinction of performance relative to the ACT Readiness Benchmarks in English, mathematics, reading, and science.

The ACT Readiness Levels categorize scores into four performance levels with three cut scores for each subject and grade: a high cut score above the Benchmark, the Benchmark, and a low cut score below the Benchmark.

The four ACT Readiness Levels are as follows.

- Exceeding: at or above the high cut score
- Ready: at or above the Benchmark and below the high cut score
- Close: at or above the low cut score and below the Benchmark
- In Need of Support: below the low cut score

Each of the four ACT Readiness Levels is intended to provide a description of how students perform relative to the ACT Readiness Benchmarks in each subject area.

The high and low cut scores were set according to the standard error of measurement (SEM; e.g., Geisinger, 1991). Specifically, the high cut score was set to be two SEMs above the Benchmark, and the low cut score was set to be two SEMs below the Benchmark for all subjects, where SEM was based on data from a special study conducted in spring 2013 (refer to Appendix E for data description). Two SEMs was chosen because it represents a substantial deviation from the Benchmark. Under typical assumptions, two standard errors from the Benchmark create a roughly 95% confidence interval around the Benchmark; we can be about 95% confident that scores falling outside this range are above or below the Benchmark. Values other than two SEMs could have been chosen to define the ACT Readiness Levels, but two SEMs is far enough away from the Benchmark to distinguish the levels of Exceeding and In Need of Support from the Benchmark in terms of statistical characteristics. Table 9.5 presents Benchmarks as well as the low and high cut scores for each subject and grade.

**Table 9.5. Benchmarks, Low Cut Scores, and High Cut Scores for ACT Readiness Levels by Subject and Grade**

| Subject | Tested Grade | Low Cut Score | Benchmark | High Cut Score |
|---|---|---|---|---|
| English | 3 | 408 | 413 | 418 |
| | 4 | 411 | 417 | 423 |
| | 5 | 412 | 419 | 426 |
| | 6 | 413 | 420 | 427 |
| | 7 | 413 | 421 | 429 |
| | 8 | 415 | 422 | 429 |
| | 9 | 419 | 426 | 433 |
| | 10 | 421 | 428 | 435 |
| Mathematics | 3 | 409 | 413 | 417 |
| | 4 | 411 | 416 | 421 |
| | 5 | 412 | 418 | 424 |
| | 6 | 414 | 420 | 426 |
| | 7 | 416 | 422 | 428 |
| | 8 | 419 | 425 | 431 |
| | 9 | 422 | 428 | 434 |
| | 10 | 426 | 432 | 438 |
| Reading | 3 | 411 | 415 | 419 |
| | 4 | 412 | 417 | 422 |
| | 5 | 415 | 420 | 425 |
| | 6 | 416 | 421 | 426 |
| | 7 | 417 | 423 | 429 |
| | 8 | 418 | 424 | 430 |
| | 9 | 419 | 425 | 431 |
| | 10 | 422 | 428 | 434 |
| Science | 3 | 414 | 418 | 422 |
| | 4 | 415 | 420 | 425 |
| | 5 | 417 | 422 | 427 |
| | 6 | 418 | 423 | 428 |
| | 7 | 420 | 425 | 430 |
| | 8 | 422 | 427 | 432 |
| | 9 | 424 | 430 | 436 |
| | 10 | 426 | 432 | 438 |

## 9.2.4 Readiness Ranges for Reporting Categories

In order to provide students with detailed information within each subject, items that measure the same skills are grouped into reporting categories. For each reporting category, the total number of points possible, the number of points earned, and the percentage of points earned are provided.

In addition, the ACT Readiness Range in each reporting category is provided to show the reporting category score typically attained for students who met the ACT Readiness Benchmark. In this way students can compare the percentage of points they obtained in each category to the percentage of points attained by a typical student who is on track for college readiness. If their scores fall below the ACT Readiness Range, they may be in need of additional support.

The minimum of the ACT Readiness Range for each reporting category corresponds to the predicted percent correct needed to be at the ACT Readiness Benchmark for the corresponding subject test in that reporting category. The maximum corresponds to 100% correct. Regression was used to predict the percent correct for students scoring at the Benchmark in each reporting category. Note that in general, the minimum of the ACT Readiness Range differs across test forms.

# 9.3 Progress Toward Career Readiness

The Progress Toward Career Readiness (PTCR) indicator is provided for students in grades 8–10 to predict performance on the ACT WorkKeys® National Career Readiness Certificate® (NCRC) taken toward the end of high school. ACT Aspire's PTCR indicator is derived from a student's ACT Aspire Composite score and is linked indirectly to actual NCRC performance through the ACT Composite score. Specially, longitudinal data were used to link students' ACT Aspire Composite score in each of grades 8–10 to their ACT Composite score in grade 11, and the ACT Composite score and performance on the ACT NCRC were linked through a single-group design where students took the ACT test and the WorkKeys Assessments in a short period of time.

Beginning in fall 2019, an updated PTCR indicator is reported, reflecting changes in how ACT and ACT Aspire Composite scores are linked to the ACT NCRC levels. Before that, the indicator provided an estimate of the next NCRC level students are progressing toward, but it often over-predicted a student's actual NCRC level and was not aligned to the interpretation of the Progress Toward the ACT NCRC indicator used for the ACT. In contrast, the updated indicator predicts NCRC level and is consistent with the methodology and interpretation employed in deriving ACT Readiness Benchmarks for grades 8–10. Furthermore, in 2018, the ACT Composite cut scores for the Progress Toward the ACT NCRC indicator were updated so that they correspond to the refreshed WorkKeys (Radunzel & Fang, 2018). Updating ACT Aspire's PTCR indicator ensures alignment to the changes made to the WorkKeys Assessments for the ACT NCRC levels.

Table 9.6 shows the updated ACT Aspire Composite score ranges linked to each NCRC level for grades 8 through 10. Based on the spring 2018 data, Allen (2018) compared the original and updated ACT Composite score ranges and provided the impact of this update on predictions of students' NCRC levels. More details can be found in this technical report.

**Table 9.6. ACT Aspire Composite Scores Corresponding to Each Predicted NCRC Level**

| Grade | Predicted NCRC Level | ACT Aspire Composite Score Range |
|---|---|---|
| 8 | No medal | 400–409 |
| | Bronze | 410–420 |
| | Silver | 421–427 |
| | Gold | 428–433 |
| | Platinum | 434–449 |
| 9 | No medal | 400–409 |
| | Bronze | 410–420 |
| | Silver | 421–428 |
| | Gold | 429–434 |
| | Platinum | 435–452 |
| 10 | No medal | 400–410 |
| | Bronze | 411–421 |
| | Silver | 422–430 |
| | Gold | 431–437 |
| | Platinum | 438–452 |

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# Chapter 10

# Scaling and Equating

## 10.1 Overview

This chapter introduces the construction of the vertical score scales and the procedures of score equating for the ACT Aspire Summative Assessments, including the four subject tests (English, mathematics, reading, and science) and the writing test.

## 10.2 Vertical Scaling

ACT Aspire tests are designed to measure student achievement and key college and career readiness constructs in a way that recognizes knowledge and skills are not isolated to specific grades, but rather progress across grades. For ACT Aspire, ACT ascribes to what Kolen and Brennan (2014) referred to as a domain definition of growth, where student achievement over the entire range of content is considered. This concept of student growth leads naturally to a vertical scaling data collection design.

In a special study conducted in 2013, ACT employed a scaling test design to establish the vertical scale for the four ACT Aspire subject tests. For a single subject, the scaling test design involved creating a whole scaling test split into four individual scaling tests that covered the range of content and difficulty across grades 3 through 11. After the test administration, the four scaling tests were recombined into one scaling test, and a vertical scale with desired psychometric properties for each targeted grade (i.e., grades 3 to early high school) was created. For each grade, scores on the on-grade test items were then linked to the vertical score scale through equating. Details of the vertical scaling study for ACT Aspire is documented in Appendix E, in which the philosophy of the ACT Aspire scaling process, the scaling study design, data collection, and data analysis as well as the evaluation of the vertical scale are addressed.

Scaling for the ACT Aspire writing tests was different from the scaling for the four subject tests because the scaling for writing test scores was rubric driven; therefore, writing scale scores do not have a vertical scale interpretation like the four subject tests. Writing scale scores are not reported to students but only contribute to computation of the ACT Aspire ELA score.

# 10.3 Equating Designs, Methods, and Procedures

The ACT Aspire Assessment System is a live testing program with ongoing item and test development. For the ACT Aspire Summative Assessments, multiple test forms are developed periodically. Despite being constructed to follow the same content and statistical specifications, test forms may differ slightly in difficulty. Equating is used to adjust for differences in difficulty among forms so that scale scores reported to students have the same meaning regardless of the specific form administrated. Through equating, statistical adjustments are made so that scores on the forms can be used interchangeably (e.g., Holland & Dorans, 2006; Kolen & Brennan, 2014).

For ACT Aspire, equating studies are conducted separately for online and paper testing modes. To ensure ACT Aspire scale scores are comparable regardless of testing modes, the paper base form was linked to the online base form through a random groups design with equipercentile equating, using data collected from the comparability study in spring 2013. Similarly, in each equating study, a random groups design is typically used with test forms spiraled during a test administration. That is, the anchor and new test forms are interspersed within a classroom so that randomly equivalent groups of students take each form. If groups are indeed randomly equivalent, observed differences in test performance across forms can be attributed to differences in form difficulty; equating methods are then applied to adjust for these differences. For each equating study, a carefully selected sample of students from an operational administration of ACT Aspire is used as an equating sample. Spiraling occurs separately for paper and online test forms; a large sample of students take each form.

Whenever needed, ACT Aspire equating uses a common-item nonequivalent groups design to improve the quality of test forms. For example, in the situation where test specifications are modified to align with certain content standards, a common-item equating design is implemented to collect student data across administrations. A revised anchor form is first equated to its original version using a common-item nonequivalent groups design, and then the new forms are equated to the revised anchor using a random equivalent groups design.

Regardless of the data collection design, once collected, equating data are checked for spiraling appropriateness and answer key correctness and then reviewed for irregular student testing behaviors before equating data analysis is performed. Using an equipercentile equating method (e.g., Kolen & Brennan, 2014), scores on parallel test forms are equated and then placed on the vertical score scale. In equipercentile equating, scores on different test forms are considered equivalent if they have the same percentile rank in a given group of students. Equipercentile equating is applied to the raw scores for each subject test separately.

The equipercentile equating results in score equivalents that are subsequently smoothed using an analytic method described in Kolen (1984); they are then rounded to integers. The resulting score conversions are used to transform raw scores on the new forms to scale scores. For ACT Aspire, equating is done separately by more than one psychometrician with expertise in equating methodologies.

For the four ACT Aspire subjects as well as the writing test, scores on the new test forms are equated. Other reported scores, such as the Composite score, the English language arts (ELA) score, the science, technology, engineering, and mathematics (STEM) score, and the reporting category scores are not equated directly. The Composite, ELA, and STEM scores are a rounded arithmetic average of the scale scores from two or more tests. Within the same grade, they are comparable across test forms because the scores used to compute them have been equated. More information on these scores is provided in Chapter 8. Reporting category scores are calculated using the number of earned points; see Chapter 3 for the descriptions of reporting category scores and Chapter 11 for the corresponding technical information.

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Chapter 11

# Reliability and Measurement Error

## 11.1 Overview

The measurement of cognitive characteristics contains some degree of inconsistency or error. A student who took one form of a test on one occasion and a second, parallel form on another occasion would likely earn somewhat different scores on the two administrations. These differences might be due to the student or the testing situation, such as different motivations, different levels of distractions across occasions, or student growth between testing events. Differences across testing occasions might also be due to the particular sample of test items or prompts included on each test form. While procedures are in place to reduce differences across testing occasions, differences cannot be eliminated.

Reliability coefficients are estimates of the consistency of test scores. They typically range from zero to one, with values near one indicating greater consistency and those near zero indicating little or no consistency. The standard error of measurement (SEM) is closely related to test reliability. The SEM summarizes the amount of error or inconsistency in scores on a test. As the *Standards for Educational and Psychological Testing* stated: “For each total score, subscore, or combination of scores that is to be interpreted, estimates of relevant indices of reliability/precision should be reported” (AERA, APA, & NCME, 2014, p. 43). In this chapter, we provided the methods and a set of statistics that quantify the reliability, measurement error, and classification consistency of the ACT Aspire subject test scores, combined scores, and indicators.

## 11.2 Reliability and Standard Error of Measurement

For a single test administration, reliability estimates of a test based on the internal structure of the response data can be calculated using the inter-item covariances. The coefficient alpha (Cronbach, 1951) is one of the most widely used estimates of the internal reliability index and was computed for the four ACT Aspire subject test scores (i.e., English, mathematics, reading, and science). The coefficient alpha can be computed using the formula

$$\hat{\alpha} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\Sigma_{i=1}^{k} s_i^2}{s_x^2}\right)$$

where $k$ is the number of test items, $s_i^2$ is the sample variance of the $i$th item, $s_{ij}$ is the sample covariance between item $i$ and item $j$, and $s_x^2$ is the sample variance of the observed total raw score.

Although coefficient alpha is often used to estimate test reliability based on the internal structure of test data, it can, at times, underestimate the true value of test reliability depending on the characteristics of the specific test under consideration. In computing the raw score reliability for the ACT Aspire tests, the stratified coefficient alpha (Cronbach, Schönemann, & McKie, 1965; Feldt & Brennan, 1989) and the congeneric reliability coefficient (Gilmer & Feldt, 1983) were also computed as a check on the coefficient alpha. All three reliability coefficients produced nearly equal values for the four ACT Aspire subject tests at each grade. As a result, for ACT Aspire, only the coefficient alpha was used in reporting raw score reliability.

Since the ACT Aspire scale was developed under the framework of the unidimensional item response theory (IRT; e.g., Birnbaum, 1968; Lord, 1980), for ACT Aspire, we apply IRT models to obtain estimates of scale score reliability and conditional standard errors of measurement (CSEMs). In the unidimensional IRT models, the person trait parameter commonly denoted as theta ($\theta$) represents an examinee's proficiency. In addition to the person parameter, IRT models contain item parameters representing items' psychometric characteristics (e.g., item difficulty, item discrimination, etc.). Additional details regarding IRT models applied to ACT Aspire can be found in Chapter 10 and Appendix E as scaling and equating methods are addressed.

To compute the CSEM for ACT Aspire scale scores, the procedures in Kolen, Hanson, and Brennan (1992) are used. The Lord-Wingersky recursive algorithm and its extension (e.g., Lord & Wingersky, 1984; Hanson, 1994; Kolen & Brennan, 2014) are first used to estimate $f(X = x | \theta_i)$, the conditional distribution of the expected raw scores $X$ given a theta value $\theta_i$. Then, with a maximum number ($K$) of raw score points and an observed scale score $sc(X)$, the CSEM of scale scores conditional on $\theta_i$ is given by

$$CSEM[sc(X \mid \theta_i)] = \{\textstyle\sum_{x=0}^{K} [sc(x) - \xi(\theta_i)]^2 f(X = x \mid \theta_i\}^{1/2},$$

where $\xi(\theta_i) = \sum_{x=0}^{K} sc(x) f(X = x \mid \theta_i)$ is the true scale score given $\theta_i$. The scale score reliability is computed using the formula

$$\rho_{sc(x)} = 1 - \frac{\sigma^2_{E_{sc(x)}}}{\sigma^2[sc(X)]},$$

where $\sigma^2_{E_{SC(X)}}$ is the aggregate error variance over the $\theta$ distribution and $\sigma^2[SC(X)]$ is the variance of observed scale scores. The aggregate error variance is given by $\sigma^2_{E_{SC(X)}} = \int_\theta var[SC(X)|\theta]g(\theta)d\theta$, where $g(\theta)$ is the population distribution of $\theta$. Computationally, $g(\theta)$ is approximated by a discrete distribution of a finite number (denoted $q$) of equally spaced points on the $\theta$ continuum such as quadrature points ($\theta_q$) and associated weights [$w(\theta_q)$]. Consequently, the aggregate error variance can be approximated by $\sigma^2_{E_{SC(X)}} = \sum_{q=1}^{Q} var[SC(X)|\theta_q]w(\theta_q)$, where $var[SC(x)|\theta_q]$ is the scale score error variance given $\theta_i$. The approximate can then be applied to the computation for an estimate of scale score reliability. For more details regarding the procedure of estimating the reliability and CSEM for scale scores, see Kolen and Brennan (2014).

Rater consistency or agreement is used to indicate the variability associated with raters or ratings for scores on writing prompts. To quantify the consistency among ratings by well-trained, randomly parallel raters, Pearson correlation is used for the ACT Aspire writing test scores. A detailed description is provided later in this chapter.

## 11.2.1 Reliability, SEM, and CSEM for ACT Aspire Subject Test Scores

For English, mathematics, reading, and science, results of the raw score reliability based on multiple operational test forms administered in the 2017–2018 academic year are listed in Table 11.1. Since more than one form was evaluated, in the table we computed the range of the raw score reliability estimates for each testing mode per subject and grade; test data from grades 9 and 10 were combined to evaluate the early high school (EHS) forms. Since raw scores of the four subject test scores were not reported, SEMs associated with the reliability estimate were not included.

For a single subject and grade, raw score reliability estimates for online forms had a similar range as those for paper forms, indicating that the internal structures of ACT Aspire test forms were quite parallel. Across grades, test forms for EHS tended to have the highest reliability estimates regardless of test subjects. In general, science test forms tended to have the highest reliability estimates among all the subjects.

Based on the same data in Table 11.1, results of the scale score reliability and SEM for the four ACT Aspire subject tests are presented in Table 11.2. Ranges of the estimates are provided, taking into account results from multiple test forms. As shown in the table, for a single subject and grade, scale score reliability estimates for online forms had a similar range as those for paper forms, which corresponded to the finding on the raw score reliability. Across online and paper testing modes, the ranges of SEM for one mode did not differ by much from the ranges for another mode. However, within the same subject, the SEMs tended to increase as the grade increased due to the wider scale score ranges for higher grades.

**Table 11.1. Ranges of Raw Score Reliability for ACT Aspire Subject Test Scores by Grade and Testing Mode**

| Grade | Mode | English | Mathematics | Reading | Science |
|---|---|---|---|---|---|
| 3 | Online | 0.83–0.87 | 0.83–0.87 | 0.84–0.87 | 0.86–0.90 |
| | Paper | 0.83–0.86 | 0.84–0.88 | 0.83–0.87 | 0.85–0.90 |
| 4 | Online | 0.82–0.87 | 0.82–0.87 | 0.84–0.87 | 0.86–0.90 |
| | Paper | 0.81–0.86 | 0.84–0.87 | 0.82–0.86 | 0.85–0.88 |
| 5 | Online | 0.82–0.87 | 0.83–0.87 | 0.82–0.86 | 0.86–0.89 |
| | Paper | 0.81–0.88 | 0.82–0.87 | 0.82–0.86 | 0.85–0.88 |
| 6 | Online | 0.84–0.86 | 0.85–0.87 | 0.84–0.86 | 0.88–0.90 |
| | Paper | 0.84–0.86 | 0.85–0.88 | 0.84–0.85 | 0.86–0.89 |
| 7 | Online | 0.85–0.88 | 0.86–0.87 | 0.84–0.87 | 0.88–0.91 |
| | Paper | 0.85–0.86 | 0.87–0.88 | 0.82–0.86 | 0.86–0.90 |
| 8 | Online | 0.85–0.88 | 0.87–0.88 | 0.81–0.86 | 0.89–0.91 |
| | Paper | 0.85–0.87 | 0.86–0.88 | 0.80–0.83 | 0.88–0.89 |
| EHS | Online | 0.90–0.91 | 0.88–0.90 | 0.82–0.87 | 0.90–0.91 |
| | Paper | 0.91–0.92 | 0.88–0.90 | 0.82–0.87 | 0.89–0.91 |

**Table 11.2. Ranges of Scale Score Reliability and SEM for ACT Aspire Subject Test Scores by Testing Mode and Grade**

| | | | Online | | Paper | |
|---|---|---|---|---|---|---|
| Subject | Grade | Number of Items | Reliability | SEM | Reliability | SEM |
| English | 3 | 31 | 0.84–0.86 | 2.33–2.57 | 0.84–0.86 | 2.44–2.59 |
| | 4 | 31 | 0.83–0.86 | 2.54–2.81 | 0.82–0.85 | 2.39–2.71 |
| | 5 | 31 | 0.83–0.87 | 2.58–2.88 | 0.83–0.86 | 2.80–3.05 |
| | 6 | 35 | 0.84–0.86 | 3.08–3.34 | 0.82–0.85 | 3.24–3.59 |
| | 7 | 35 | 0.85–0.88 | 3.08–3.35 | 0.85–0.86 | 3.33–3.50 |
| | 8 | 35 | 0.85–0.88 | 3.31–3.78 | 0.85–0.86 | 3.03–3.11 |
| | EHS | 50 | 0.91–0.91 | 3.17–3.23 | 0.91–0.92 | 3.03–3.20 |
| Mathematics | 3 | 30 | 0.83–0.86 | 1.46–1.61 | 0.84–0.87 | 1.57–1.73 |
| | 4 | 30 | 0.82–0.87 | 1.52–1.85 | 0.83–0.87 | 1.64–1.84 |
| | 5 | 30 | 0.81–0.85 | 2.00–2.24 | 0.82–0.86 | 2.10–2.25 |
| | 6 | 36 | 0.85–0.87 | 2.01–2.11 | 0.86–0.88 | 2.35–2.55 |
| | 7 | 36 | 0.87–0.87 | 2.57–2.65 | 0.87–0.88 | 2.80–2.88 |
| | 8 | 42 | 0.87–0.88 | 2.76–3.14 | 0.87–0.89 | 2.61–2.92 |
| | EHS | 42 | 0.88–0.90 | 2.76–3.19 | 0.88–0.90 | 2.97–3.21 |
| Reading | 3 | 24 | 0.86–0.88 | 1.91–2.08 | 0.84–0.86 | 1.95–2.06 |
| | 4 | 24 | 0.86–0.87 | 2.24–2.34 | 0.83–0.85 | 2.20–2.33 |
| | 5 | 24 | 0.84–0.87 | 2.36–2.62 | 0.83–0.85 | 2.34–2.50 |
| | 6 | 24 | 0.85–0.86 | 2.52–2.67 | 0.84–0.84 | 2.56–2.62 |
| | 7 | 24 | 0.83–0.87 | 2.39–2.69 | 0.83–0.85 | 2.44–2.63 |
| | 8 | 24 | 0.83–0.87 | 2.76–3.14 | 0.80–0.82 | 2.67–2.83 |
| | EHS | 24 | 0.84–0.87 | 2.93–3.21 | 0.83–0.86 | 2.92–3.06 |
| Science | 3 | 32 | 0.86–0.90 | 2.12–2.45 | 0.87–0.89 | 1.97–2.18 |
| | 4 | 32 | 0.87–0.89 | 2.14–2.34 | 0.86–0.88 | 2.14–2.24 |
| | 5 | 32 | 0.86–0.89 | 2.12–2.37 | 0.85–0.86 | 2.10–2.20 |
| | 6 | 36 | 0.89–0.90 | 2.14–2.22 | 0.88–0.88 | 2.23–2.32 |
| | 7 | 36 | 0.90–0.90 | 2.29–2.45 | 0.88–0.89 | 2.47–2.59 |
| | 8 | 36 | 0.89–0.91 | 2.49–2.74 | 0.88–0.89 | 2.54–2.67 |
| | EHS | 36 | 0.90–0.91 | 2.74–2.88 | 0.89–0.91 | 2.60–2.89 |

Whereas the SEM provides an average measure of score variability across the entire score scale, the CSEM quantifies the uncertainty at a particular score. Figures 11.1 and 11.2 present the CSEMs for the four subject-test scale scores using one form administered in the 2017–2018 academic year. The CSEM was not necessarily graphed for very low scale scores which can be obtained by guessing or random responding or which few students obtain. The CSEMs for different grades did not end at the same scale score point because the highest obtainable scale score was not constant across grades (see Appendix E for the ACT Aspire scale development). Within a subject, the CSEM patterns over online and paper modes did not differ by much for most grades. For mathematics, the CSEMs for some grades were high at the upper end of the true score scale, perhaps due to relatively few examinees achieving these scores.

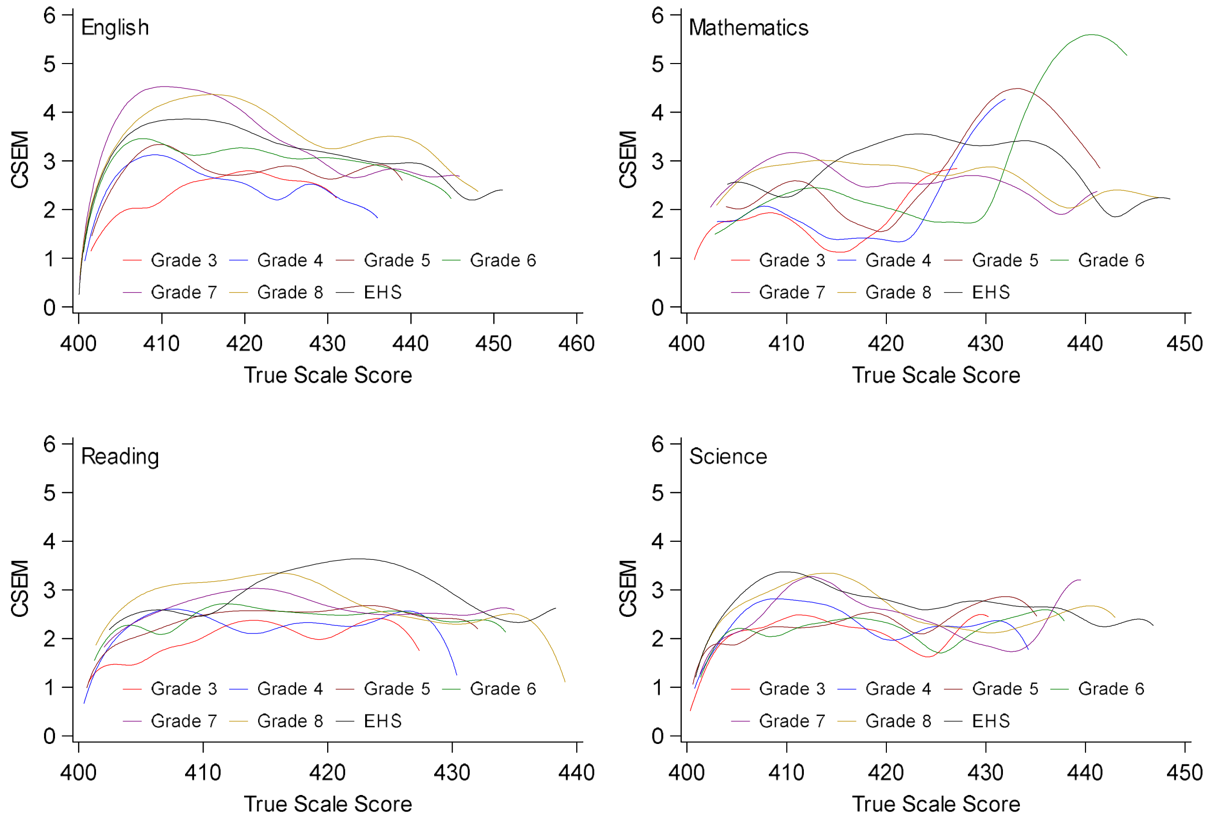



**Figure 11.1. CSEM for English, mathematics, reading, and science online test forms across grades.**

Figure 11.1. CSEM for English, mathematics, reading, and science online test forms across grades.

Figure 11.1. CSEM for English, mathematics, reading, and science online test forms across grades.

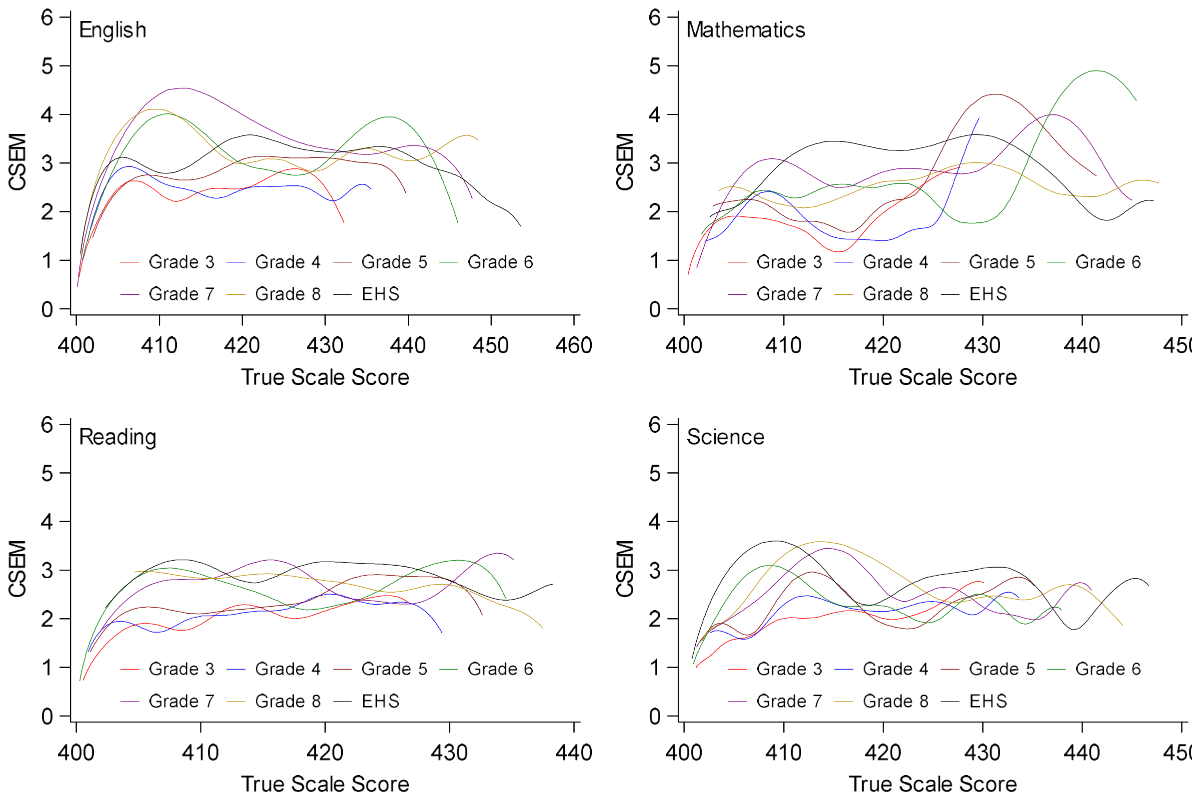



Figure 11.2. CSEM for English, mathematics, reading, and science paper test forms across grades.

Figure 11.2. CSEM for English, mathematics, reading, and science paper test forms across grades.



## 11.2.2 Reliability, SEM, and CSEM for ACT Aspire Composite, ELA, and STEM Scores

For ACT Aspire, students who have valid scale scores on English, mathematics, reading, and science tests receive a Composite score. Similarly, those who have valid scale scores on English, reading, and writing tests receive an ELA score, and those who have valid mathematics and science scale scores receive a STEM score (see Chapter 8 for the formation of ACT Aspire scores). At the individual student level, each combined score has an unrounded CSEM by $\sigma_E = 1/k\sqrt{\sum_{j=1}^{k}\sigma_{E_j}^2}$, where $k$ is the number of subject tests contributing to the combined scores (i.e., $k = 4$ for the Composite score; $k = 3$ for the ELA score; and $k = 2$ for the STEM score), and $\sigma_{E_j}^2$ refers to the scale score measurement error variance for subject test $j$ (see Section 11.2 for the computation of $\sigma_{E_j}^2$). The individual CSEMs were fitted with a quadratic polynomial against the unrounded CSEMs. Finally, for a combined score, the SEM for scale scores is obtained by taking the square root of the average conditional error variances over all students. The scale score reliability is computed as described in section 11.2, with the squared SEM of the combined score as the numerator and the observed combined score variance as the denominator in the far-right term of the equation.

The scale score reliability and SEM for the ACT Aspire Composite, ELA, and STEM scores for all the operational test forms administered in the 2017–2018 academic year are presented in Table 11.3. The scale score reliability estimates were fairly high for Composite scores, with values of 0.95 or greater for all grades scale score reliability estimates were fairly high for Composite scores, with values of 0.95 or greater for all grades; they were also high for ELA and STEM scores, with values of 0.90 or greater. For these combined scores, the SEMs tended to get higher as the grade increased.

**Table 11.3. Scale Score Reliability and SEM for the ACT Aspire Combined Scores**

| | Composite | | ELA | | STEM | |
|---|---|---|---|---|---|---|
| Grade | Reliability | SEM | Reliability | SEM | Reliability | SEM |
| 3 | 0.95 | 1.04 | 0.90 | 1.46 | 0.92 | 1.33 |
| 4 | 0.95 | 1.10 | 0.90 | 1.43 | 0.92 | 1.40 |
| 5 | 0.95 | 1.22 | 0.91 | 1.55 | 0.91 | 1.56 |
| 6 | 0.95 | 1.31 | 0.90 | 1.79 | 0.93 | 1.56 |
| 7 | 0.95 | 1.38 | 0.92 | 1.66 | 0.93 | 1.82 |
| 8 | 0.96 | 1.44 | 0.92 | 1.70 | 0.93 | 1.93 |
| EHS | 0.97 | 1.49 | 0.94 | 1.75 | 0.94 | 2.03 |

For Composite, ELA, and STEM scores, the CSEM is plotted against the true scale score in Figures 11.3, 11.4, and 11.5, respectively. For each grade, a random sample of 5,000 student examinees was selected and used for plotting. For grade 3, the CSEM values for the Composite score were around 1 and fell between 1 and 2 for other grades. For the ELA score, the CSEM values were within 1 and 2 for most grades but increased for about a half point for grades 6, 8, and EHS. For the STEM score, the CSEM values were within 1 and 2 for lower grades (i.e., grades 3 through 6) and tended to be spread at the higher end of the true score scale; for higher grades, the CSEM values were roughly within 1.5 and 2.5, indicating that overall, the CSEM values tended to be high as the grade increased.

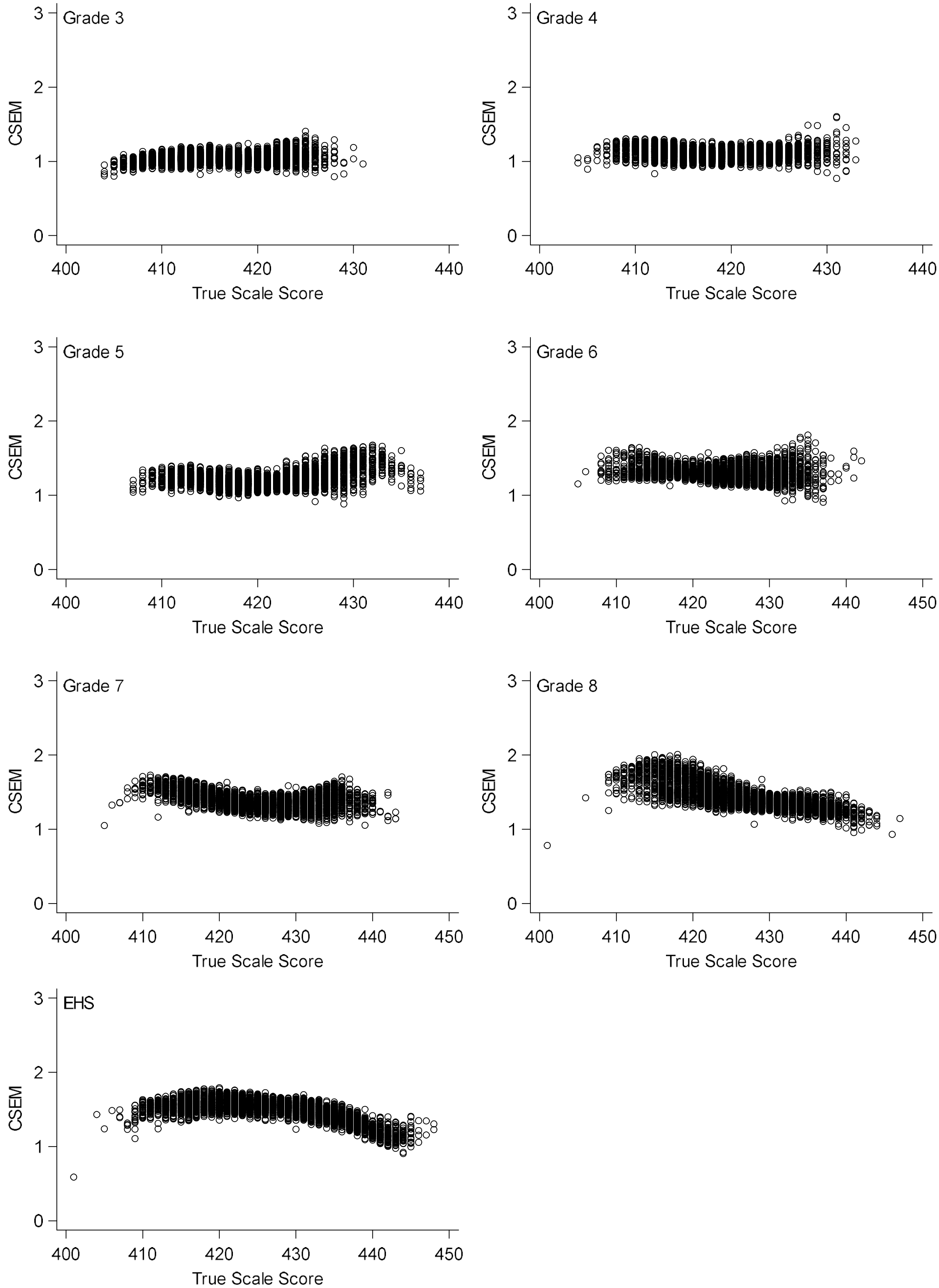



**Figure 11.3. CSEM for Composite scores by grade.**

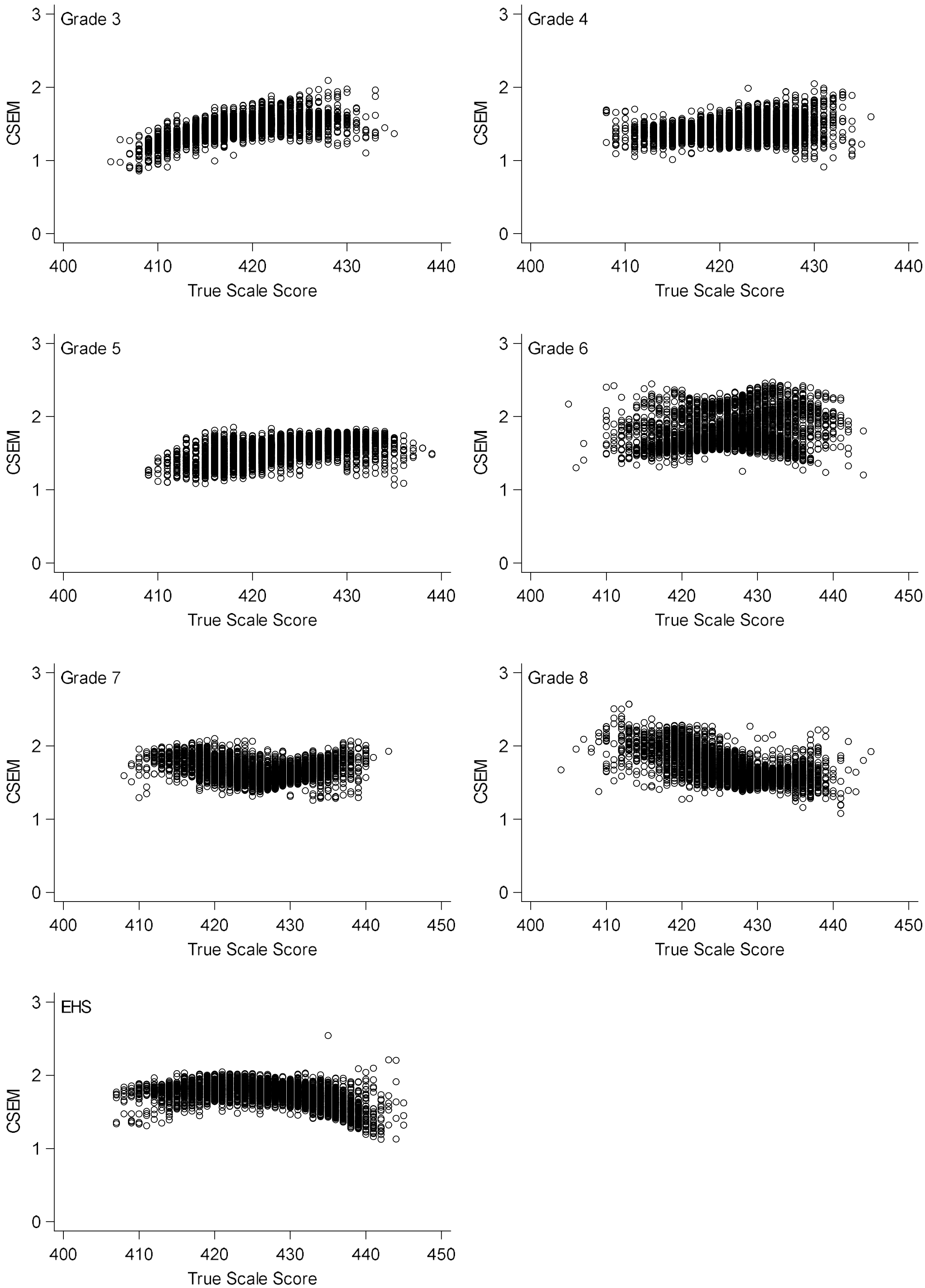
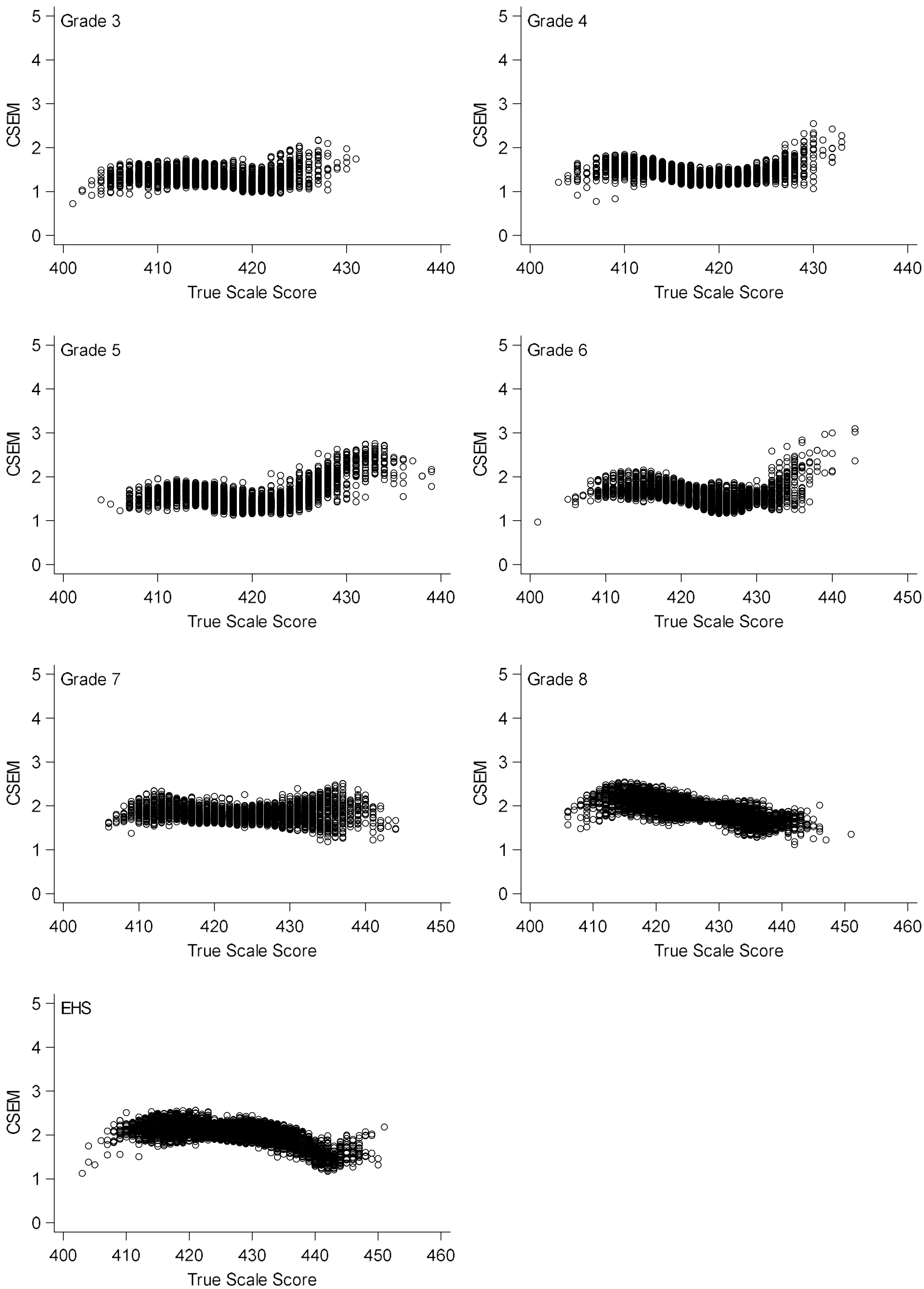



**Figure 11.4 CSEM for ELA scores by grade.**




**Figure**

**11.5. CSEM for STEM scores by grade.**

11.10

# 11.2.3 Reliability and SEM for ACT Aspire Reporting Category Scores

For each subject test, in addition to the subject test scores, ACT Aspire also reports student performance by reporting category scores. For each reporting category, the percent and number of points students earn out of the total number of possible points are provided. The total number of possible points in each reporting category may vary across forms, as indicated in the following tables (e.g., number of items) and as discussed in Chapter 3. For each reporting category, we computed raw score reliabilities (i.e., coefficient alpha) and standard errors of measurement (SEMs) based on the multiple operational test forms administered in the 2017–2018 academic year. Based on the corresponding reliability estimate and the raw score standard deviation, the SEM was obtained by the generic form: SEM = SD*(1-reliability)$^{1/2}$. By grade and testing mode, Tables 11.4, 11.5, 11.6, and 11.7 contain the results for English, mathematics, reading, and science, respectively.

**Table 11.4. For English Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 3 | POW | 12–14 | 0.66–0.74 | 1.48–1.69 | 12–14 | 0.66–0.75 | 1.48–1.65 |
| | COE | 17–19 | 0.75–0.80 | 1.70–1.88 | 17–19 | 0.76–0.79 | 1.63–1.86 |
| 4 | POW | 8–9 | 0.62–0.68 | 1.16–1.35 | 9–9 | 0.56–0.72 | 1.23–1.33 |
| | KLA | 3–4 | 0.41–0.59 | 0.66–0.83 | 3–3 | 0.31–0.59 | 0.61–0.76 |
| | COE | 19–19 | 0.70–0.80 | 1.85–1.95 | 19–19 | 0.68–0.78 | 1.81–1.94 |
| 5 | POW | 9–10 | 0.58–0.73 | 1.27–1.38 | 9–10 | 0.55–0.73 | 1.25–1.36 |
| | KLA | 3–3 | 0.40–0.49 | 0.67–0.73 | 3–3 | 0.39–0.49 | 0.63–0.71 |
| | COE | 18–19 | 0.68–0.78 | 1.75–1.89 | 18–19 | 0.71–0.79 | 1.70–1.80 |
| 6 | POW | 11–11 | 0.65–0.71 | 1.36–1.48 | 11–11 | 0.67–0.70 | 1.34–1.46 |
| | KLA | 3–4 | 0.36–0.48 | 0.72–0.84 | 3–4 | 0.31–0.47 | 0.72–0.80 |
| | COE | 20–21 | 0.72–0.78 | 1.86–2.00 | 20–21 | 0.74–0.78 | 1.79–1.95 |
| 7 | POW | 10–11 | 0.68–0.69 | 1.33–1.42 | 10–11 | 0.66–0.70 | 1.30–1.44 |
| | KLA | 4–5 | 0.29–0.63 | 0.75–0.98 | 4–5 | 0.26–0.57 | 0.71–0.99 |
| | COE | 20–21 | 0.78–0.82 | 1.86–1.96 | 20–21 | 0.75–0.79 | 1.84–1.87 |
| 8 | POW | 9–11 | 0.62–0.76 | 1.24–1.43 | 9–11 | 0.64–0.73 | 1.21–1.39 |
| | KLA | 4–5 | 0.40–0.65 | 0.84–0.89 | 4–5 | 0.29–0.55 | 0.80–0.87 |
| | COE | 20–21 | 0.74–0.81 | 1.84–1.93 | 20–21 | 0.77–0.81 | 1.75–1.86 |
| EHS[b] | POW | 13–13 | 0.74–0.77 | 1.49–1.57 | 13–13 | 0.76–0.81 | 1.47–1.53 |
| | KLA | 6–8 | 0.55–0.71 | 0.99–1.28 | 6–8 | 0.53–0.71 | 0.96–1.27 |
| | COE | 29–31 | 0.84–0.86 | 2.19–2.40 | 29–31 | 0.86–0.87 | 2.14–2.34 |

[a] For reporting categories, POW = production of writing ; KLA = knowledge of language; and COE = conventions of standard English. [b] EHS: Early high school forms taken by students in grades 9 and 10.

**Table 11.5. For Mathematics Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade—continued**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 3 | GLP | 21–21 | 0.75–0.82 | 1.95–2.13 | 21–21 | 0.75–0.81 | 2.00–2.23 |
| | NBT | 3–3 | 0.40–0.59 | 0.66–0.76 | 3–3 | 0.29–0.59 | 0.68–0.70 |
| | NF | 4–4 | 0.40–0.52 | 0.84–0.87 | 4–4 | 0.40–0.53 | 0.83–0.87 |
| | OA | 6–6 | 0.51–0.66 | 0.96–1.05 | 6–6 | 0.50–0.65 | 1.01–1.03 |
| | G | 3–3 | 0.29–0.37 | 0.64–0.78 | 3–3 | 0.33–0.37 | 0.68–0.78 |
| | MD | 4–4 | 0.15–0.53 | 0.80–0.86 | 4–4 | 0.14–0.51 | 0.86–0.89 |
| | IES | 9–9 | 0.63–0.70 | 1.53–1.80 | 9–9 | 0.60–0.73 | 1.53–1.89 |
| | JE | 3–3 | 0.57–0.62 | 1.23–1.46 | 3–3 | 0.57–0.64 | 1.20–1.58 |
| | Modeling | 9–19 | 0.61–0.79 | 1.57–2.30 | 11–18 | 0.65–0.77 | 1.58–2.28 |
| 4 | GLP | 20–20 | 0.73–0.81 | 1.94–2.02 | 20–20 | 0.75–0.80 | 2.00–2.09 |
| | NBT | 5–5 | 0.44–0.56 | 0.83–0.97 | 5–5 | 0.46–0.55 | 0.91–0.93 |
| | NF | 5–5 | 0.40–0.62 | 0.93–0.99 | 5–5 | 0.44–0.61 | 0.93–0.99 |
| | OA | 3–3 | 0.13–0.51 | 0.71–0.74 | 3–3 | 0.21–0.54 | 0.72–0.81 |
| | G | 3–3 | 0.25–0.34 | 0.67–0.74 | 3–3 | 0.12–0.37 | 0.73–0.81 |
| | MD | 3–3 | 0.35–0.44 | 0.63–0.73 | 3–3 | 0.34–0.45 | 0.72–0.76 |
| | IES | 10–10 | 0.63–0.74 | 1.59–1.77 | 10–10 | 0.67–0.74 | 1.53–1.76 |
| | JE | 3–3 | 0.53–0.66 | 1.20–1.38 | 3–3 | 0.51–0.69 | 1.13–1.38 |
| | Modeling | 10–17 | 0.60–0.82 | 1.39–2.23 | 11–18 | 0.62–0.82 | 1.45–2.29 |
| 5 | GLP | 21–21 | 0.79–0.81 | 1.94–2.06 | 21–21 | 0.77–0.81 | 1.96–2.13 |
| | NBT | 5–5 | 0.45–0.56 | 0.92–1.00 | 5–5 | 0.48–0.55 | 0.94–0.99 |
| | NF | 5–5 | 0.55–0.68 | 0.88–0.94 | 5–5 | 0.51–0.62 | 0.87–0.96 |
| | OA | 3–3 | 0.31–0.48 | 0.67–0.77 | 3–3 | 0.35–0.44 | 0.70–0.77 |
| | G | 4–4 | 0.21–0.43 | 0.79–0.91 | 4–4 | 0.23–0.53 | 0.78–0.92 |
| | MD | 3–3 | 0.09–0.47 | 0.69–0.72 | 3–3 | 0.11–0.43 | 0.70–0.76 |

[a] For reporting categories from grades 3 through EHS, GLP = grade level progress; IES = integrating essential skills; and JE = justification & explanation. For those from grades 3 through 5, NBT = numbers & operations in base 10; NF = numbers & operations—fractions; OA = operations & algebraic thinking; G = geometry; and MD = measurement & data. For those from grades 6 through 8, NS = the number system; EE = expressions & equations; RP = ratios & proportional relationships (grades 6 & 7); F = functions (grade 8); G = geometry; and S = statistics & probability. For reporting categories for EHS, N = number & quantity; A = algebra; F = functions; G = geometry; and S = statistics & probability. [b] EHS: Early high school forms taken by students in grades 9 and 10.

**Table 11.5. For Mathematics Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade—continued**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 5—cont'd | IES | 9–9 | 0.51–0.72 | 1.45–1.61 | 9–9 | 0.56–0.74 | 1.47–1.63 |
| | JE | 3–3 | 0.46–0.54 | 1.08–1.26 | 3–3 | 0.48–0.54 | 1.12–1.28 |
| | Modeling | 14–19 | 0.62–0.79 | 1.75–2.15 | 15–19 | 0.67–0.80 | 1.84–2.17 |
| 6 | GLP | 24–24 | 0.80–0.82 | 2.08–2.26 | 24–24 | 0.80–0.83 | 2.05–2.28 |
| | NS | 5–5 | 0.43–0.56 | 0.92–1.00 | 5–5 | 0.50–0.59 | 0.94–0.97 |
| | EE | 6–6 | 0.50–0.67 | 0.97–1.03 | 6–6 | 0.41–0.60 | 1.00–1.07 |
| | RP | 4–4 | 0.31–0.53 | 0.82–0.87 | 4–4 | 0.31–0.50 | 0.74–0.88 |
| | G | 4–4 | 0.37–0.59 | 0.81–0.86 | 4–4 | 0.36–0.59 | 0.80–0.86 |
| | S | 4–4 | 0.31–0.46 | 0.84–0.88 | 4–4 | 0.39–0.41 | 0.82–0.87 |
| | IES | 12–12 | 0.66–0.69 | 1.62–1.91 | 12–12 | 0.67–0.72 | 1.62–1.96 |
| | JE | 3–3 | 0.50–0.60 | 0.90–1.33 | 3–3 | 0.50–0.65 | 0.87–1.41 |
| | Modeling | 16–18 | 0.73–0.80 | 1.80–1.85 | 14–20 | 0.71–0.78 | 1.66–1.92 |
| 7 | GLP | 24–24 | 0.79–0.85 | 2.14–2.24 | 24–24 | 0.80–0.84 | 2.18–2.31 |
| | NS | 4–4 | 0.40–0.51 | 0.81–0.89 | 4–4 | 0.43–0.60 | 0.78–0.84 |
| | EE | 6–6 | 0.45–0.59 | 0.98–1.10 | 6–6 | 0.48–0.60 | 1.00–1.11 |
| | RP | 5–5 | 0.36–0.63 | 0.91–0.96 | 5–5 | 0.40–0.63 | 0.93–0.97 |
| | G | 4–4 | 0.29–0.44 | 0.83–0.93 | 4–4 | 0.25–0.47 | 0.82–0.93 |
| | S | 4–4 | 0.23–0.58 | 0.80–0.84 | 4–4 | 0.31–0.56 | 0.80–0.84 |
| | IES | 12–12 | 0.61–0.70 | 1.62–1.91 | 12–12 | 0.64–0.73 | 1.69–1.93 |
| | JE | 3–3 | 0.55–0.63 | 1.05–1.49 | 3–3 | 0.58–0.65 | 1.06–1.56 |
| | Modeling | 12–17 | 0.60–0.76 | 1.43–1.76 | 13–19 | 0.67–0.78 | 1.49–1.86 |
| 8 | GLP | 28–28 | 0.81–0.82 | 2.37–2.51 | 28–28 | 0.79–0.83 | 2.36–2.51 |
| | NS | 3–3 | 0.19–0.48 | 0.70–0.78 | 3–3 | 0.25–0.37 | 0.71–0.76 |
| | EE | 7–7 | 0.54–0.58 | 1.13–1.16 | 7–7 | 0.47–0.60 | 1.12–1.16 |

[a] For reporting categories from grades 3 through EHS, GLP = grade level progress; IES = integrating essential skills; and JE = justification & explanation. For those from grades 3 through 5, NBT = numbers & operations in base 10; NF = numbers & operations—fractions; OA = operations & algebraic thinking; G = geometry; and MD = measurement & data. For those from grades 6 through 8, NS = the number system; EE = expressions & equations; RP = ratios & proportional relationships (grades 6 & 7); F = functions (grade 8); G = geometry; and S = statistics & probability. For reporting categories for EHS, N = number & quantity; A = algebra; F = functions; G = geometry; and S = statistics & probability. [b] EHS: Early high school forms taken by students in grades 9 and 10.

**Table 11.5. For Mathematics Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade—continued**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 8—cont'd | F | 6–6 | 0.34–0.61 | 1.03–1.10 | 6–6 | 0.34–0.61 | 1.06–1.09 |
| | G | 7–7 | 0.42–0.62 | 1.11–1.17 | 7–7 | 0.40–0.59 | 1.12–1.16 |
| | S | 4–4 | 0.28–0.53 | 0.83–0.91 | 4–4 | 0.24–0.49 | 0.87–0.90 |
| | IES | 14–14 | 0.69–0.74 | 1.70–1.95 | 14–14 | 0.69–0.76 | 1.65–2.03 |
| | JE | 3–3 | 0.52–0.65 | 1.18–1.34 | 3–3 | 0.52–0.64 | 1.19–1.43 |
| | Modeling | 11–14 | 0.60–0.68 | 1.44–1.87 | 11–14 | 0.62–0.71 | 1.44–1.88 |
| EHS [b] | GLP | 28–28 | 0.82–0.84 | 2.30–2.38 | 28–28 | 0.83–0.85 | 2.34–2.39 |
| | N | 3–3 | 0.17–0.48 | 0.69–0.77 | 3–3 | 0.25–0.47 | 0.71–0.75 |
| | A | 7–7 | 0.47–0.62 | 1.05–1.19 | 7–7 | 0.52–0.66 | 1.07–1.17 |
| | F | 6–6 | 0.49–0.54 | 1.04–1.08 | 6–6 | 0.49–0.55 | 1.04–1.07 |
| | G | 7–7 | 0.45–0.56 | 1.11–1.19 | 7–7 | 0.50–0.55 | 1.13–1.16 |
| | S | 4–4 | 0.30–0.45 | 0.78–0.89 | 4–4 | 0.25–0.44 | 0.77–0.88 |
| | IES | 14–14 | 0.72–0.81 | 1.81–1.97 | 14–14 | 0.71–0.78 | 1.83–2.03 |
| | JE | 3–3 | 0.65–0.72 | 1.12–1.28 | 3–3 | 0.66–0.69 | 1.13–1.33 |
| | Modeling | 17–21 | 0.77–0.85 | 1.71–1.93 | 18–20 | 0.78–0.82 | 1.79–1.99 |

[a] For reporting categories from grades 3 through EHS, GLP = grade level progress; IES = integrating essential skills; and JE = justification & explanation. For those from grades 3 through 5, NBT = numbers & operations in base 10; NF = numbers & operations—fractions; OA = operations & algebraic thinking; G = geometry; and MD = measurement & data. For those from grades 6 through 8, NS = the number system; EE = expressions & equations; RP = ratios & proportional relationships (grades 6 & 7); F = functions (grade 8); G = geometry; and S = statistics & probability. For reporting categories for EHS, N = number & quantity; A = algebra; F = functions; G = geometry; and S = statistics & probability. [b] EHS: Early high school forms taken by students in grades 9 and 10.

**Table 11.6. For Reading Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 3 | KID | 14–15 | 0.76–0.80 | 1.77–1.89 | 14–15 | 0.74–0.80 | 1.84–1.85 |
| | CAS | 7–8 | 0.62–0.69 | 1.12–1.24 | 7–8 | 0.58–0.73 | 1.09–1.22 |
| | IOK | 2–2 | 0.21–0.38 | 0.88–1.03 | 2–2 | 0.22–0.34 | 1.03–1.13 |
| 4 | KID | 14–15 | 0.78–0.81 | 1.79–1.84 | 14–15 | 0.76–0.79 | 1.80–1.85 |
| | CAS | 7–8 | 0.62–0.65 | 1.14–1.21 | 7–8 | 0.59–0.65 | 1.12–1.19 |
| | IOK | 2–2 | 0.30–0.46 | 0.86–1.20 | 2–2 | 0.27–0.38 | 0.96–1.22 |
| 5 | KID | 14–15 | 0.72–0.79 | 1.61–1.96 | 14–15 | 0.74–0.76 | 1.60–1.85 |
| | CAS | 7–8 | 0.57–0.74 | 1.13–1.36 | 7–8 | 0.57–0.75 | 1.13–1.36 |
| | IOK | 2–2 | 0.23–0.26 | 1.18–1.25 | 2–2 | 0.21–0.33 | 1.19–1.24 |
| 6 | KID | 14–15 | 0.75–0.80 | 1.79–1.93 | 14–15 | 0.75–0.79 | 1.77–1.98 |
| | CAS | 7–8 | 0.55–0.67 | 1.00–1.24 | 7–8 | 0.58–0.67 | 0.99–1.14 |
| | IOK | 2–2 | 0.14–0.37 | 0.96–1.18 | 2–2 | 0.06–0.33 | 1.00–1.18 |
| 7 | KID | 14–15 | 0.76–0.81 | 1.70–1.86 | 14–15 | 0.74–0.81 | 1.66–1.79 |
| | CAS | 7–8 | 0.61–0.69 | 1.08–1.19 | 7–8 | 0.56–0.65 | 1.08–1.19 |
| | IOK | 2–2 | 0.28–0.45 | 1.02–1.05 | 2–2 | 0.21–0.40 | 1.02–1.13 |
| 8 | KID | 14–15 | 0.70–0.79 | 1.71–2.05 | 14–15 | 0.70–0.75 | 1.78–2.04 |
| | CAS | 7–8 | 0.59–0.71 | 1.07–1.22 | 7–8 | 0.55–0.68 | 1.04–1.19 |
| | IOK | 2–2 | 0.21–0.27 | 1.21–1.46 | 2–2 | 0.15–0.25 | 1.22–1.29 |
| EHS [b] | KID | 14–15 | 0.74–0.81 | 1.55–2.15 | 14–15 | 0.73–0.84 | 1.48–2.11 |
| | CAS | 7–8 | 0.44–0.68 | 1.11–1.55 | 7–8 | 0.52–0.72 | 1.09–1.60 |
| | IOK | 2–3 | 0.19–0.42 | 1.39–1.57 | 2–3 | 0.18–0.40 | 1.24–1.53 |

[a] For reporting categories, KID = key ideas and details; CAS = craft and structure; and IOK = integration of knowledge and ideas.
[b] EHS: Early high school forms taken by students in grades 9 and 10.

**Table 11.7. For Science Reporting Category Scores, Ranges of Number of Items, Raw Score Reliability, and SEM by Testing Mode and Grade**

| | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Reporting Category [a] | Number of Items | Reliability | SEM | Number of Items | Reliability | SEM |
| 3 | IOD | 17–18 | 0.78–0.85 | 1.81–1.89 | 17–18 | 0.77–0.85 | 1.78–1.85 |
| | SIN | 7–8 | 0.57–0.67 | 1.28–1.32 | 7–8 | 0.57–0.64 | 1.27–1.32 |
| | EMI | 6–8 | 0.62–0.67 | 1.16–1.37 | 6–8 | 0.62–0.66 | 1.20–1.36 |
| 4 | IOD | 17–20 | 0.79–0.85 | 1.73–1.98 | 17–20 | 0.77–0.83 | 1.77–2.04 |
| | SIN | 6–8 | 0.55–0.57 | 1.14–1.32 | 6–8 | 0.53–0.58 | 1.16–1.32 |
| | EMI | 6–8 | 0.49–0.66 | 1.15–1.36 | 6–8 | 0.52–0.64 | 1.13–1.37 |
| 5 | IOD | 16–20 | 0.79–0.84 | 1.76–1.91 | 16–20 | 0.77–0.80 | 1.77–1.84 |
| | SIN | 6–8 | 0.58–0.69 | 1.10–1.29 | 6–8 | 0.56–0.69 | 1.09–1.26 |
| | EMI | 6–8 | 0.52–0.64 | 1.21–1.30 | 6–8 | 0.51–0.64 | 1.17–1.30 |
| 6 | IOD | 18–20 | 0.80–0.83 | 1.88–1.91 | 18–20 | 0.78–0.81 | 1.84–1.90 |
| | SIN | 7–9 | 0.67–0.70 | 1.21–1.36 | 7–9 | 0.64–0.68 | 1.24–1.32 |
| | EMI | 9–11 | 0.69–0.75 | 1.31–1.54 | 9–11 | 0.66–0.72 | 1.29–1.53 |
| 7 | IOD | 18–19 | 0.82–0.83 | 1.64–1.89 | 18–19 | 0.78–0.80 | 1.56–1.83 |
| | SIN | 7–8 | 0.64–0.69 | 1.22–1.37 | 7–8 | 0.62–0.66 | 1.19–1.40 |
| | EMI | 10–11 | 0.73–0.79 | 1.42–1.45 | 10–11 | 0.70–0.77 | 1.37–1.43 |
| 8 | IOD | 16–17 | 0.77–0.84 | 1.68–1.93 | 16–17 | 0.75–0.79 | 1.63–1.95 |
| | SIN | 7–9 | 0.63–0.70 | 1.19–1.36 | 7–9 | 0.63–0.66 | 1.17–1.35 |
| | EMI | 10–12 | 0.75–0.79 | 1.51–1.70 | 10–12 | 0.75–0.78 | 1.54–1.68 |
| EHS [b] | IOD | 15–17 | 0.81–0.85 | 1.71–1.76 | 15–17 | 0.78–0.84 | 1.69–1.74 |
| | SIN | 9–9 | 0.63–0.68 | 1.32–1.50 | 9–9 | 0.62–0.69 | 1.32–1.52 |
| | EMI | 10–12 | 0.75–0.79 | 1.50–1.62 | 10–12 | 0.75–0.79 | 1.50–1.60 |

[a] For reporting categories, IOD = interpretation of data; SIN = scientific investigation; and EMI = evaluation of models, inferences, and experimental results. [b] EHS: Early high school forms taken by students in grades 9 and 10.

# 11.2.4 Rater Consistency for ACT Aspire Writing Scores

Tests that consist of a single item typically use different types of information to estimate raw score reliability. For a test like ACT Aspire writing, which consists of a single writing prompt, one aspect of score reliability is rater consistency. While it should not be confused with score reliability, rater consistency is an important contributor to the reliability of writing scores. For a single prompt, the correlation between writing scores provided by two independent raters can be an indicator of rater consistency.

In the ACT Aspire operational administration during the 2017–2018 academic year, for each grade, a subsample of students received two ratings for their responses to the writing prompt. Each response was rated on four domains, or traits: ideas and analysis, development and support, organization, and language use and conventions. Scores on these domains were combined to yield a total score. While the correlation for the total score indicates rater consistency, the inter-trait correlations for the four domain scores can be viewed as evidence of internal consistency for a writing prompt.

Table 11.8 contains the Pearson correlations between the two sets of ratings on the four domains as well as the sum of four domain scores, which was used as an indicator on the overall writing performance. Due to small sample sizes for paper testing, the results of correlations in the table were only based on writing responses from online testing. Across grades, the correlations for the total writing score were moderately high, ranging from a low of 0.79 in grade 3 to a high of 0.86 for EHS. Correlations for domain scores ranged from 0.65 (in ideas and analysis for grade 3) to 0.81 (in organization for EHS). Overall, the correlations were slightly higher for development and support than other domains.

**Table 11.8. Writing Test Score Correlations Between Two Ratings by Domain and for Total Score**

| Grade | Ideas and Analysis | Development and Support | Organization | Language Use and Conventions | Total Score |
|---|---|---|---|---|---|
| 3 | 0.65 | 0.71 | 0.68 | 0.67 | 0.79 |
| 4 | 0.77 | 0.76 | 0.74 | 0.76 | 0.83 |
| 5 | 0.70 | 0.76 | 0.72 | 0.75 | 0.83 |
| 6 | 0.77 | 0.79 | 0.78 | 0.77 | 0.83 |
| 7 | 0.74 | 0.75 | 0.73 | 0.72 | 0.83 |
| 8 | 0.75 | 0.76 | 0.75 | 0.74 | 0.84 |
| EHS | 0.80 | 0.80 | 0.81 | 0.78 | 0.86 |

# 11.3 Classification Consistency

Classification consistency refers to the extent to which examinees are classified into the same category over replications of a measurement procedure. Because tests are rarely administered twice to the same examinee, classification consistency is typically estimated from a single test administration, with strong assumptions about distributions of measurement errors and true scores (e.g., Hanson & Brennan, 1990; Livingston & Lewis, 1995).

Using the method described by Livingston and Lewis (1995), the true score distribution was estimated by fitting data with a four-parameter beta distribution. The expected conditional distribution of scores, given the true score, is a binomial distribution. Assuming errors of measurement are independent, given the true score, the probabilities that a student would be classified into each pair of categories (assuming the test was administered twice) were computed. The conditional results were then aggregated over the true score distribution to get a contingency table containing probabilities of a student receiving scores from two administrations that fall into any combination of categories. The estimated classification consistency index for the whole group is the sum of the values on the diagonal of the contingency table; this index represents the probabilities of being classified in the same category on two separate administrations. Below are classification consistency results for the ACT Aspire test scores and indicators.

## 11.3.1 Classification Consistency for ACT Aspire Subject Test Scores

For ACT Aspire English, mathematics, reading, and science tests, classification is based on the ACT Readiness Benchmarks and the ACT Readiness Levels (see Chapter 9 for detail about these cut scores). Based on test scores and Benchmarks, student performance can be classified into two categories, Ready and not Ready). Further, based on test scores and ACT Readiness Level cut scores, student performance can be classified into one of four levels: Exceeding, Ready, Close, and In Need of Support. In other words, by subject and grade, classification is based on the single cut score (i.e., the ACT Readiness Benchmark) and two additional cut scores (i.e., the ACT Readiness Levels).

Classification consistency values were estimated using data from operational forms administered in the 2017–2018 academic year. Note that the ACT Readiness Benchmarks and the ACT Readiness Levels are grade based indicators and thus, the classification consistency indices for grades 9 and 10 were separately estimated. The classification consistency results are provided in Table 11.9. For each subject and grade, a range of the classification consistency values was reported based on multiple parallel forms. For ACT Readiness Benchmarks, values were high across the board, with greater classification consistency rates in English and slightly lower rates in reading. For ACT Readiness Levels, values were not as high as those for Benchmarks due to multiple cuts scores that included tails of the score distributions; relatively few examinees resided in the tails than in the middle of the distribution. In general, however, consistency rates in English tended to be higher than other subjects.

**Table 11.9. Ranges of Classification Consistency Rates for ACT Readiness Benchmarks and ACT Readiness Levels in English, Mathematics, Reading, and Science by Subject and Grade**

| | English | | | Mathematics | | |
|---|---|---|---|---|---|---|
| Grade | Number of Items | ACT Readiness Benchmark | ACT Readiness Levels | Number of Items | ACT Readiness Benchmark | ACT Readiness Levels |
| 3 | 31 | 0.83–0.87 | 0.62–0.68 | 30 | 0.83–0.85 | 0.59–0.65 |
| 4 | 31 | 0.84–0.87 | 0.61–0.67 | 30 | 0.81–0.84 | 0.62–0.68 |
| 5 | 31 | 0.84–0.86 | 0.63–0.67 | 30 | 0.80–0.85 | 0.60–0.65 |
| 6 | 35 | 0.85–0.87 | 0.64–0.67 | 36 | 0.83–0.85 | 0.62–0.66 |
| 7 | 35 | 0.88–0.90 | 0.68–0.72 | 36 | 0.84–0.85 | 0.62–0.63 |
| 8 | 35 | 0.86–0.90 | 0.65–0.72 | 42 | 0.84–0.88 | 0.61–0.66 |
| 9 | 50 | 0.87–0.89 | 0.67–0.71 | 42 | 0.86–0.88 | 0.64–0.68 |
| 10 | 50 | 0.87–0.90 | 0.68–0.72 | 42 | 0.87–0.88 | 0.66–0.68 |
| | Reading | | | Science | | |
| Grade | Number of Items | ACT Readiness Benchmark | ACT Readiness Levels | Number of Items | ACT Readiness Benchmark | ACT Readiness Levels |
| 3 | 24 | 0.83–0.87 | 0.60–0.66 | 32 | 0.85–0.87 | 0.62–0.67 |
| 4 | 24 | 0.83–0.85 | 0.59–0.63 | 32 | 0.84–0.86 | 0.61–0.64 |
| 5 | 24 | 0.83–0.86 | 0.59–0.64 | 32 | 0.83–0.86 | 0.61–0.65 |
| 6 | 24 | 0.82–0.85 | 0.57–0.62 | 36 | 0.85–0.86 | 0.63–0.65 |
| 7 | 24 | 0.82–0.85 | 0.58–0.64 | 36 | 0.85–0.86 | 0.63–0.66 |
| 8 | 24 | 0.80–0.85 | 0.55–0.61 | 36 | 0.85–0.87 | 0.63–0.67 |
| 9 | 24 | 0.83–0.87 | 0.58–0.65 | 36 | 0.86–0.88 | 0.66–0.69 |
| 10 | 24 | 0.82–0.86 | 0.58–0.66 | 36 | 0.86–0.88 | 0.65–0.69 |

## 11.3.2 Classification Consistency for ACT Aspire ELA and STEM Scores

For the ACT Readiness Benchmarks for ELA and STEM scores (see Chapter 9 for the development of these Benchmarks), student performance can be classified into two categories, Ready and not Ready, based on their test scores and the Benchmarks. Classification consistency values were estimated using the same operational data used for computing classification consistency for the Readiness Benchmarks and levels of the four subject tests The classification consistency results are provided in Table 11.10. For the ACT Readiness Benchmarks for ELA and STEM scores, values were fairly high, with a range from 0.86 to 0.89 for ELA and from 0.90 to 0.93 for STEM across grades.

**Table 11.10. Classification Consistency Rates for ACT Readiness Benchmarks for ELA and STEM Scores by Grade**

| Grade | ELA | STEM |
|---|---|---|
| 3 | 0.86 | 0.91 |
| 4 | 0.86 | 0.90 |
| 5 | 0.87 | 0.92 |
| 6 | 0.86 | 0.92 |
| 7 | 0.88 | 0.92 |
| 8 | 0.88 | 0.92 |
| 9 | 0.89 | 0.93 |
| 10 | 0.89 | 0.92 |

## 11.3.3 Classification Consistency for Progress with Text Complexity Indicator

Classification consistency was also computed for two other indicators provided on ACT Aspire score reports. The first indicator is progress with text complexity (PTC), which shows whether students make sufficient progress in reading and understanding increasingly complex texts to prepare for the reading demands of college and career. From the multiple test forms administered in the 2017–2018 academic year, as in Table 11.11, the classification consistency across grades ranged from 0.69 (in grade 8 online and paper forms) to 0.84 (in grade 7 online forms), which was moderately high considering the number of items that contributed to the PTC scores. Within a grade, the numbers of items for PCT scores were quite similar over online and paper testing modes.

**Table 11.11. Ranges of Classification Consistency for Progress With Text Complexity Indicator**

| | Online | | Paper | |
|---|---|---|---|---|
| Grade | Range of Number of Items | Classification Consistency | Range of Number of Items | Classification Consistency |
| 3 | 8–10 | 0.79–0.81 | 8–11 | 0.76–0.80 |
| 4 | 10–12 | 0.74–0.81 | 10–11 | 0.73–0.79 |
| 5 | 8–11 | 0.77–0.81 | 8–11 | 0.74–0.78 |
| 6 | 8–13 | 0.79–0.80 | 9–14 | 0.76–0.79 |
| 7 | 9–14 | 0.76–0.84 | 9–13 | 0.73–0.79 |
| 8 | 8–13 | 0.69–0.81 | 8–13 | 0.69–0.77 |
| 9 | 8–12 | 0.72–0.79 | 9–11 | 0.73–0.76 |
| 10 | 8–12 | 0.73–0.79 | 9–11 | 0.71–0.74 |

## 11.3.4 Classification Consistency for Progress Toward Career Readiness Indicator

Progress Toward Career Readiness (PTCR) is an early indicator of students' future level of achievement on the ACT National Career Readiness Certificate (NCRC). The ACT NCRC is an assessment-based credential that documents foundational work skills important for job success across industries and occupations. The ACT NCRC is based on the results of the ACT WorkKeys Assessments. Scores on the ACT WorkKeys Assessments determine the certificate level—no certificate, Bronze, Silver, Gold, or Platinum—an individual can earn. The ACT NCRC gives individuals evidence that they possess the skills employers deem essential to workplace success. More information about the ACT NCRC can be found at http://workforce.act.org/credential. See Chapter 9 for a detailed description of the development of the PTCR indicator for ACT Aspire.

For ACT Aspire, across multiple forms administered in the 2017–2018 academic year, the Progress Toward Career Readiness indicator had classification consistency values of 0.79, 0.81, and 0.81 for grades 8, 9, and 10, respectively. Note that the classification consistency index is an indication of the stability of the Progress Toward Career Readiness indicator if different ACT Aspire test forms were taken, but not an indication of the accuracy of the classification compared with students' actual NCR attainment.

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# Chapter 12

# Validity Evidence

According to the *Standards for Educational and Psychological Testing* (AERA, APA, & NCME, 2014), "validity refers to the degree to which evidence and theory support the interpretations of test scores for proposed uses of tests" (p. 11). Validation is the process of justifying particular interpretations and uses and may involve logical, empirical, or theoretical components.

In this chapter, two primary and four secondary uses of ACT Aspire scores are reviewed, and evidence of the validity of ACT Aspire scores for particular uses is described. Validity evidence is organized into the following six areas, as described by The Standards (AERA et al., 2014):

1. Content
2. Cognitive processes
3. Internal structure
4. Relationships with conceptually-related constructs
5. Relationships with criteria
6. Consequences of tests

## 12.1 Uses of ACT Aspire Scores

ACT Aspire scores have two principal uses and four secondary uses. The principal uses are the following:

1. To measure progress toward meeting college and career readiness content standards
2. To measure progress toward meeting empirically-derived college and career readiness performance standards

Secondary uses of ACT Aspire scores are the following:

3. To provide instructionally actionable information to educators
4. To inform evaluation of school and program effectiveness

5. To inform readiness for advanced high school coursework
6. To understand student and group performance relative to national norms

In addition to these intended uses, test users may develop particular interpretations and uses that are not covered in this chapter or this technical manual. Each use needs to be justified by a validity argument. The evidence summarized in this technical manual can be used for validation of common interpretations and uses of ACT Aspire scores but may not be sufficient for validating all interpretations and uses. Test users should consider their specific interpretations and uses of ACT Aspire scores and may need to collect additional evidence to support them. Validity evidence will continue to be gathered and evaluated as the uses of ACT Aspire scores evolve.

It is worth noting that all intended uses of ACT Aspire scores are supported by information in other chapters of this technical manual. For example, Chapter 2 provides information related to content evidence, supporting all uses of ACT Aspire scores. Chapter 13 supports the claims of the fairness of using ACT Aspire test scores for different student subgroups. Chapter 8 provides detailed information on ACT Aspire norms, directly supporting Use 6 (to understand student and group performance relative to national norms). Chapter 14 describes how ACT Aspire scores support interpretations of student and school growth, directly supporting Use 4 (to inform evaluation of school and program effectiveness).

Some uses of ACT Aspire scores are closely related to the six intended uses, and so do not warrant being listed separately. For example, the use of ACT Aspire scores for accountability is closely related to Uses 1, 2, and 4. The use of ACT Aspire scores as a status indicator for accountability (e.g., percent meeting ACT Readiness Benchmarks) is supported by content evidence, studies examining alignment of ACT Aspire with a state's academic standards, evidence from standard setting (including development of the ACT Readiness Benchmarks), and additional evidence presented in this chapter. Similarly, using ACT Aspire scores as a growth indicator for accountability (e.g., mean student growth percentile) is supported by the same evidence, in addition to information presented in Chapter 14.

## 12.2 Content-Oriented Evidence

ACT Aspire scores for each subject (or combination of subjects) are intended to provide inferences about students' knowledge and skills (achievement or performance) in English, mathematics, reading, science, and writing. Therefore, one aspect of validation for ACT Aspire is gathering content evidence for the foundational interpretation that ACT Aspire scores are indicative of academic performance in English, mathematics, reading, science, and writing. Content evidence is a foundation for all uses of ACT Aspire scores and is arguably the most important class of evidence for supporting Use 1 (to measure progress toward meeting college and career readiness standards).

Content evidence for validity is based on the appropriateness of test content and the procedures used to specify and create test content. This evidence is based on the justifications for and the connections between

- the content domain,
- the knowledge and skills represented by the ACT Aspire content specifications,
- the development of items,

- the development of forms,
- test administration conditions, and
- item and test scoring.

Most of the descriptions and justifications for content were provided in earlier chapters, but a brief review is provided in this section.

The content domains for ACT Aspire include (a) English, reading, and writing (ELA) and (b) mathematics and science (STEM) across grades 3–10. These content domains include knowledge and skills needed for success in school and for success in college and career. ACT Aspire test forms in each subject include items intended to represent content from the broad subject area domain (see Chapter 2).

In addition, the ACT College and Career Readiness Standards (for grades 8 and above), the ACT Aspire performance-level descriptors, and the ACT Aspire grade-level targets provide statements of what students should know and be able to do to be on track for attaining college and career readiness in each subject and grade. These resources were developed by content and measurement experts and are consistent with many states' standards for college and career readiness (see Chapter 1 and Appendices A, B, C, D). Collectively, these resources help connect ACT Aspire assessment results to learning and instruction, supporting Use 3 (to provide instructionally actionable information to educators).

ACT Aspire content specifications identify the number and type of items required when each form was developed. These specifications determine the type and amount of evidence obtained within each subject and determine how representative test content is of the entire content of a subject (see Chapter 2).

Item writers are carefully chosen from a pool of qualified educators and follow standardized procedures and templates when creating items. All items undergo rigorous internal and external reviews to ensure that they are accurate, appropriate, and fair for the intended students. Each item is pretested with students from the intended ACT Aspire population to verify its quality and characteristics (see Chapters 2 and 3).

Initial ACT Aspire forms are developed to follow the content specifications. Initial forms are reviewed by content experts to determine the accuracy and appropriateness of the form. If experts determine that adjustments should be made, items may be swapped as long as they meet the content specifications. A form is final once it passes these reviews (see Chapter 2).

The standardized ACT Aspire test administration is intended to ensure that students' performance is not affected by administration characteristics. Administration practices are documented in the *ACT Aspire Room Supervisor Manual*. However, where possible, students are allowed some flexibility in the test administration to access the test in a way that meets their needs but still measures the constructs targeted by the test. A standard process is followed for documenting and providing students who need particularly strong supports, such as testing accommodations, the flexibility they need. See Chapter 5 for additional details.

ACT Aspire standardized test administrations on paper and online are as similar as possible. However, test administration conditions are different because the mode of administration is different. Paper and online modes are not assumed to be the same, partly due to potential differences in performance due to the testing mode. For example, technology-enhanced items appear only in online tests. Appendix F addresses performance differences between online and paper forms, and Chapter 10 addresses how scores are equated for online and paper modes so that scores for both modes are reported on the same scale. Treating forms from different modes separately when linking them to the ACT Aspire scale helps ensure that scores from different modes are comparable.

Item scoring procedures are described in Chapter 4, and test scoring procedures are described in Chapter 8. Rater training and procedures for scoring constructed response items are explained in Chapters 2 and 4.These procedures are applied uniformly to all students and forms so that scores consistently reflect student performance across various student, item, and test characteristics.

# 12.3 Evidence Regarding Cognitive Processes

To collect evidence about cognitive processes, researchers verify that a particular skill is indeed used by test takers. Each use of ACT Aspire test scores is indirectly supported by evidence that test takers use the intended cognitive processes.

Two approaches are commonly used to determine which cognitive processes students use. The first is to ask students what they are thinking while they work on a test. This can be particularly helpful for items that ask students to write responses because these responses provide more evidence about students' cognitive processes. The second source of evidence is student responses that have been rated. In this case, raters' consistency (i.e., accurately interpreting and applying scoring rubrics) gives evidence of students' cognitive processes.

As part of piloting constructed-response (CR) items for ACT Aspire in 2012 and 2013, students in grades 8, 10, and 11 from several schools responded to two or three CR tasks in mathematics or science. Students completed tasks in pairs or small groups by thinking aloud and discussing their strategies and reasoning processes with their group. After responding, students were asked to fill out a brief survey (e.g., what the student liked, disliked, and found confusing about the items) and engage in a brief group interview regarding their experiences with the items. These pilots helped verify that ACT Aspire CR items require students to use the intended knowledge and skills to produce their answer.

Another source of evidence regarding cognitive processes can be found in Chapters 2 and 4 describing rater training and item scoring. These processes involve carefully defined procedures and reviews to ensure the quality and validity of scores of CR items. The validity of scores is checked during scoring, and initial scores may be rejected if they do not pass quality checks. In addition, during rubric development and application, the coherence and consistency of rubrics are considered against the skill each item measures to help ensure that the rubric leads to ratings that reflect the knowledge and skills of the student.

# 12.4 Evidence Regarding Internal Structure

Evidence regarding internal structure is based on evaluating intended score interpretations from the perspective of expected characteristics among test items or parts of the test. ACT Aspire is intended to measure academic achievement in English, mathematics, reading, science, and writing. In addition, Composite,[1] ELA, and STEM scores are reported for students who take the required tests.

[1] Composite scores will be reported for all grades starting from fall 2019; prior to that, they were only reported for grade 8 and above.

Besides the single prompt for the writing test, English, mathematics, reading, and science tests are expected to be essentially unidimensional. ACT Aspire aims to measure general academic achievement in the five subjects, even though reporting category scores suggest distinct subcategories in a subject. Therefore, a dominant dimension would be expected to emerge.

A study was conducted to evaluate the extent to which ACT Aspire item performance appeared to be best represented by a single dimension. One analysis in this study is the exploratory factor analysis (EFA), which is often used to evaluate the dimensionality of performance on assessments like ACT Aspire (e.g., Sireci, 2009, p. 30). Item scores from multiple ACT Aspire forms for English, mathematics, reading, and science administered in spring 2018 were used in the study. Across subjects and grades, the minimum sample size was around 2,400 for paper forms and 5,000 for online forms. Scree plots of eigenvalues, model fit, and factor loadings were also examined.

Scree plots display eigenvalues obtained from the EFA against the number of extracted factors, and evaluation of scree plots involves identifying the "elbow" in the plot to estimate the number of dimensions to retain (Cattell, 1966). Figure 12.1 presents the scree plots of one form for each grade and subject. For the majority of the forms, the "elbow" appears after the first eigenvalue, which suggests unidimensionality. For one English form (paper form for grade 3) and a few mathematics forms (paper and online forms for grades 8 and 9), reading forms (paper forms for grades 3, 6, and 8; online form for grade 3), and science forms (paper forms for grades 3, 4, 8, and EHS; online forms for grades 4 and EHS), the "elbow" appears after the second eigenvalue, indicating that a two-factor model might fit the data better. For all the forms, the variance accounted for by the second factor did not exceed 10%. O'Rourke and Hatcher (2013) suggested that factors that account for less than 10% of the variance should not be retained. The argument for essential unidimensionality can be based on a combination of evidence from scree plots and percentage of variance accounted for.

Model fit was also evaluated for one-factor and two-factor models fitted to the data. The goodness-of-fit for each model was examined, including the chi-square test (CHISQ) and several other fit statistics to supplement CHISQ, which is sensitive to larger sample sizes. These additional statistics and their suggested ranges for good model-data fit (Hu and Bentler, 1999) include the comparative fit index (CFI; ≥ .95), the Tucker-Lewis index (TLI; ≥ .95), the root mean square error of approximation (RMSEA; ≤ .06), and the standardized root mean square of residual (SRMR; ≤ .08).

Tables 12.1–12.4 present the observed supplementary fit statistics for all the forms with scree plots shown in Figure 12.1. The observed CHISQ results are not listed because they were, as expected, statistically significant due to the large sample size. Some values of CFI, TLI, RMSEA, and SRMR showed an inadequate fit. The observed fit statistics for English, mathematics, reading, and science showed evidence for unidimensionality in most cases. Based on RMSEA and SRMR, none of the forms were flagged for inadequate fit. Based on CFI or TLI values, some forms were flagged including English (paper form for grade 3; online forms for grades 8 and EHS), reading (paper forms for grades 3 and 8; online form for grade 3), and science (paper form for grade 3). For the flagged forms, the observed values of CFI and TLI for the one-factor model were close to the cutoff values, although they were not within the desired range for good model-data fit. The two-factor model did not generally show a meaningful improvement to model fit compared to the one-factor model. The most noticeable improvement in model fit for the two-factor model was observed for reading, on paper forms for grades 3 and 8, with gains in TLI of about .08 and .07, respectively.

Factor loadings measure the strength of relationship between items and the underlying factor, and were examined to define the two factors. Factor loadings are particularly helpful when the two-factor model fits a form noticeably better because the patterns may show what each factor appears to be measuring (e.g., Gorsuch, 1983, pp. 206–212). The loadings for the two-factor model are shown in Table 12.5 for the forms on which the two-factor model showed noticeably better fit than the one-factor model (i.e., reading paper forms for grades 3 and 8). Given that the items that suggested a second factor tended to be near the end of the test, the second factor suggests that the forms exhibited some degree of speededness.

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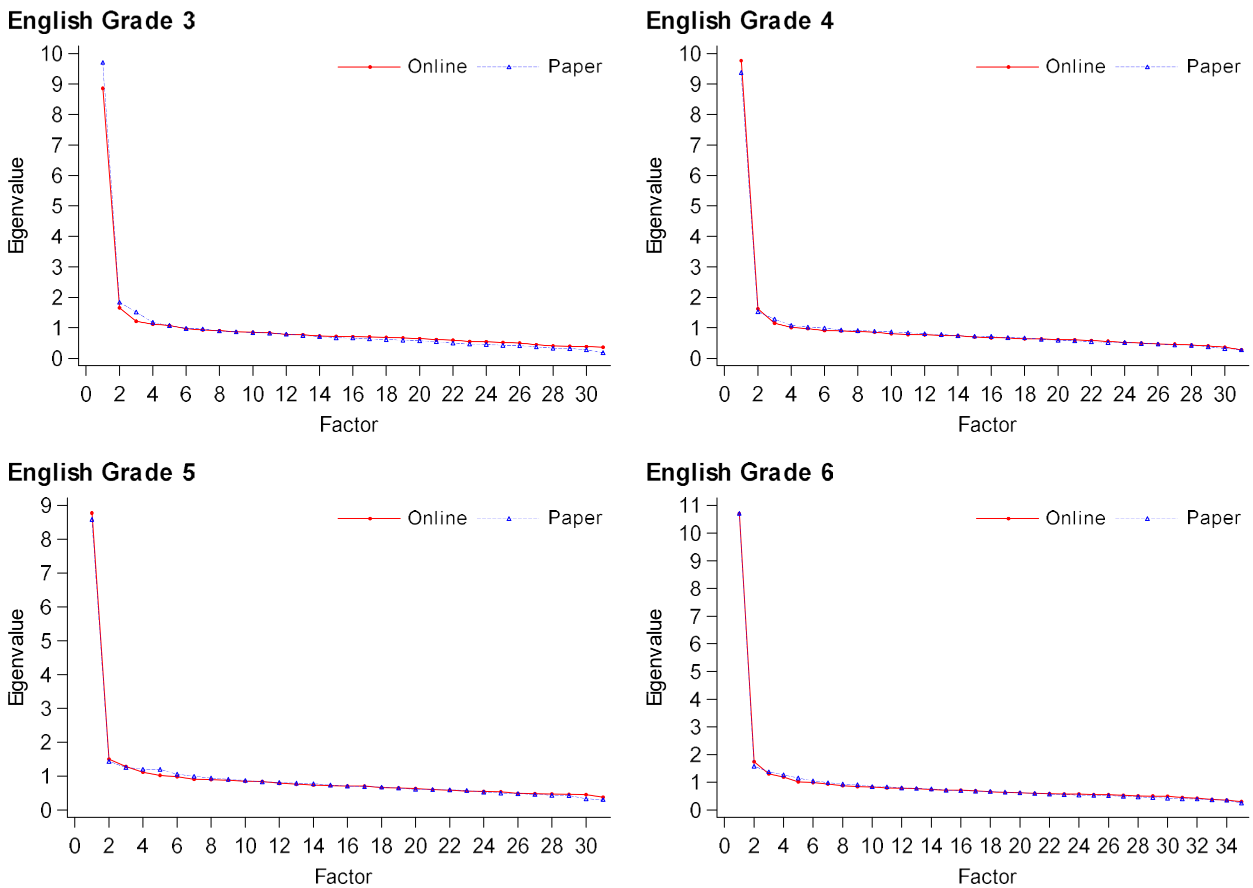


**Figure 12.1. Scree plots of ACT Aspire online and paper forms by subject and grade using data from the spring 2018 administration.**

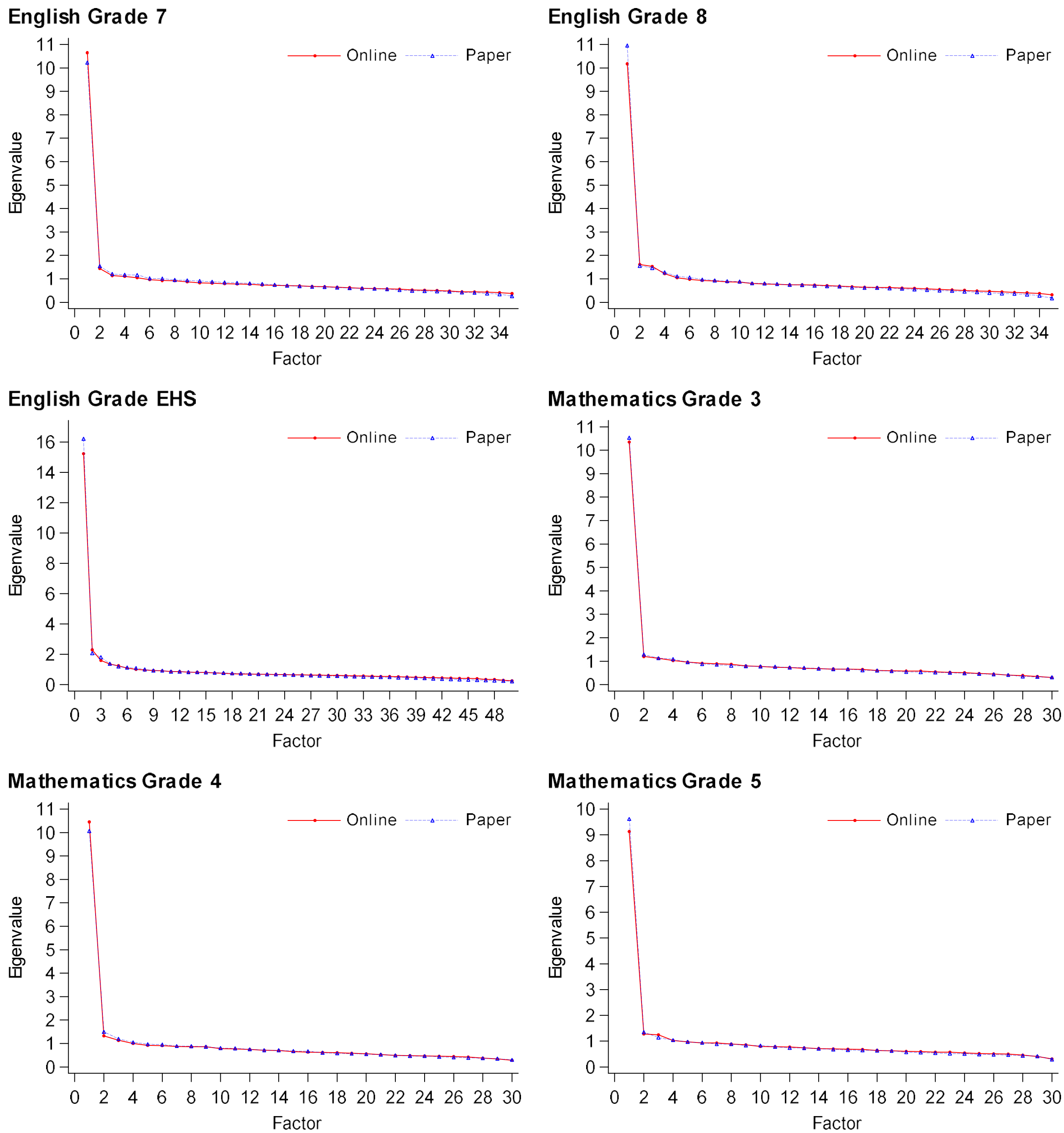


**Figure 12.1. Scree plots of ACT Aspire online and paper forms by subject and grade using data from the spring 2018 administration—continued.**

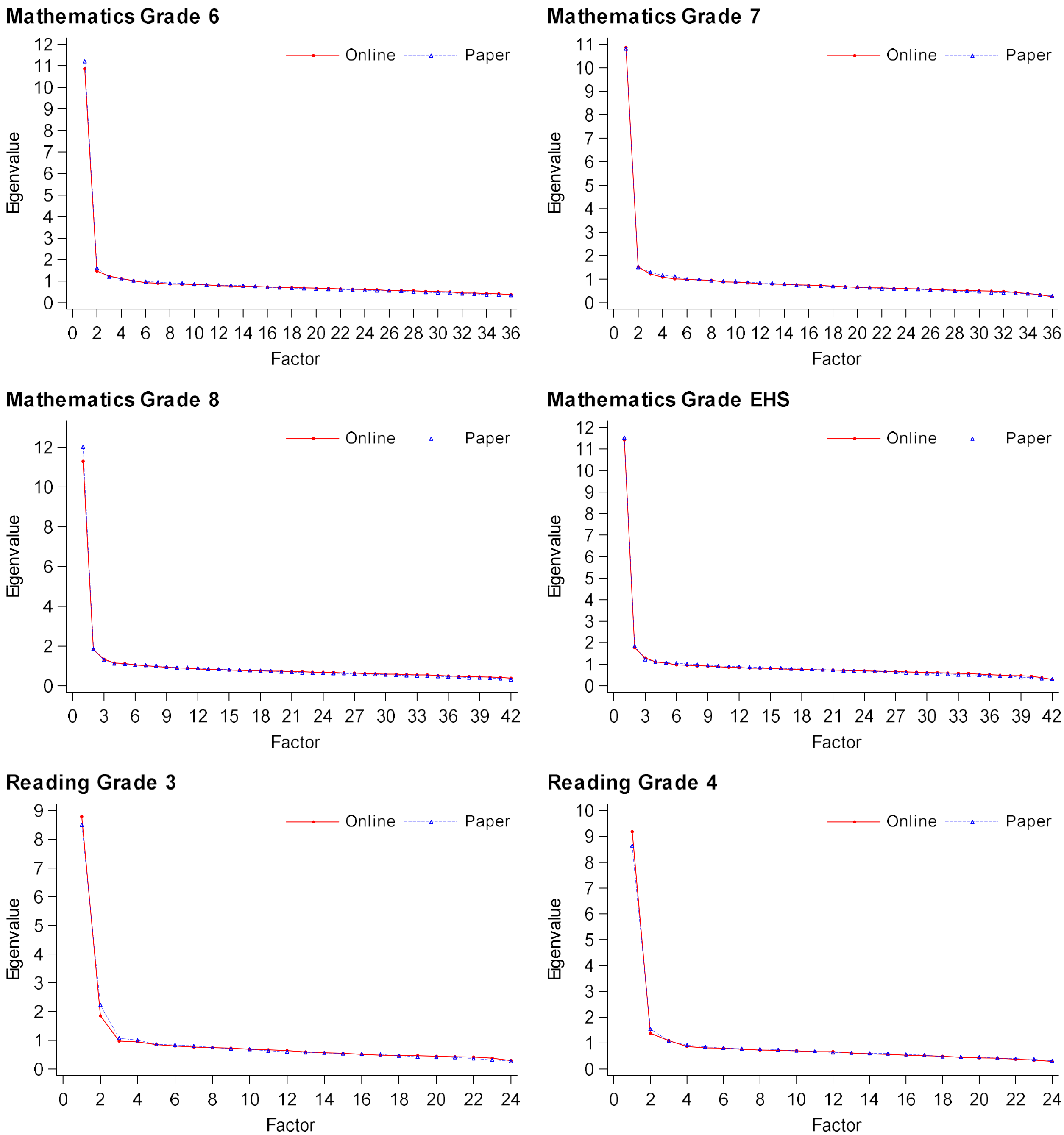


**Figure 12.1. Scree plots of ACT Aspire online and paper forms by subject and grade using data from the spring 2018 administration—continued.**

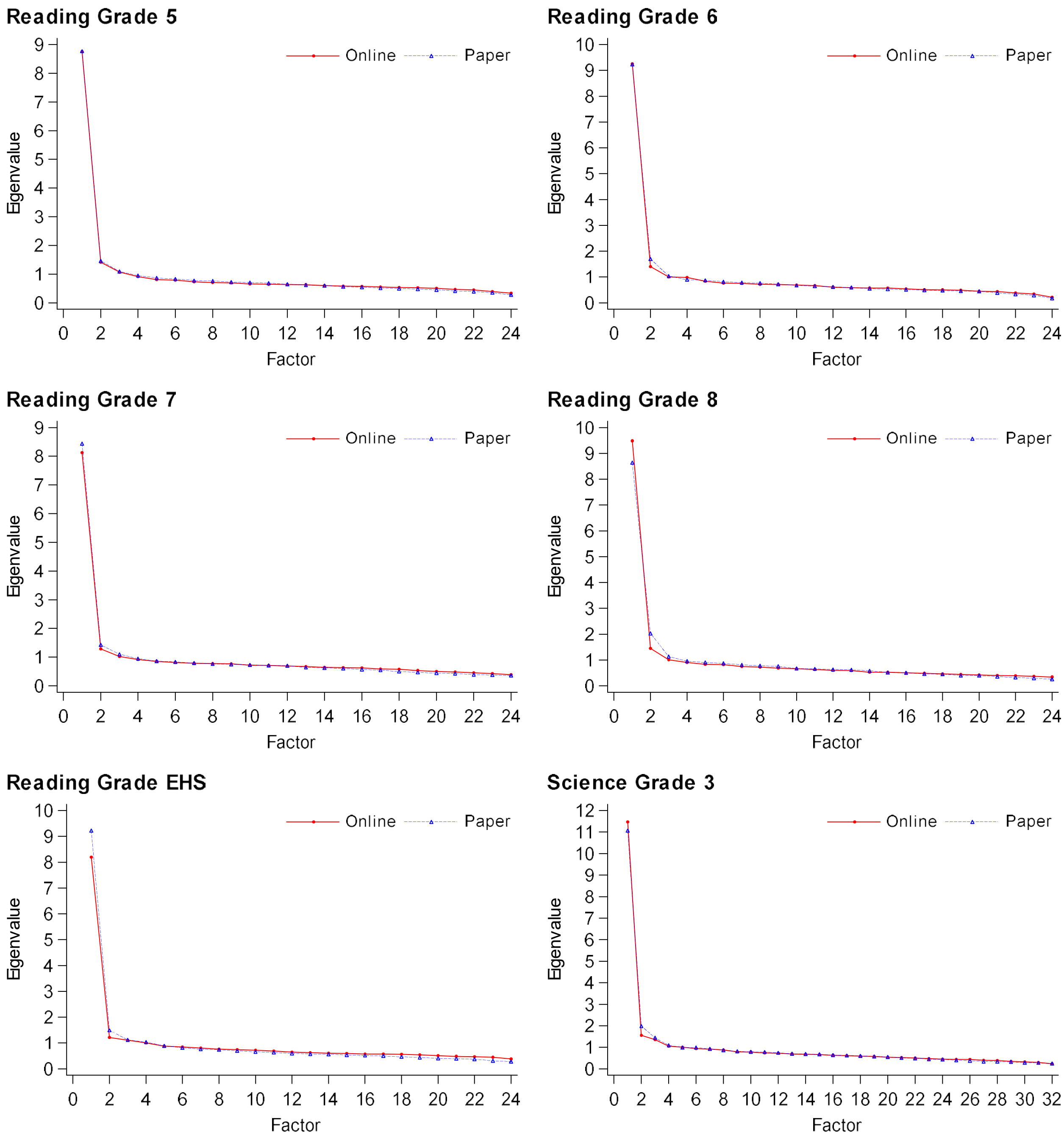


**Figure 12.1. Scree plots of ACT Aspire online and paper forms by subject and grade using data from the spring 2018 administration—continued.**

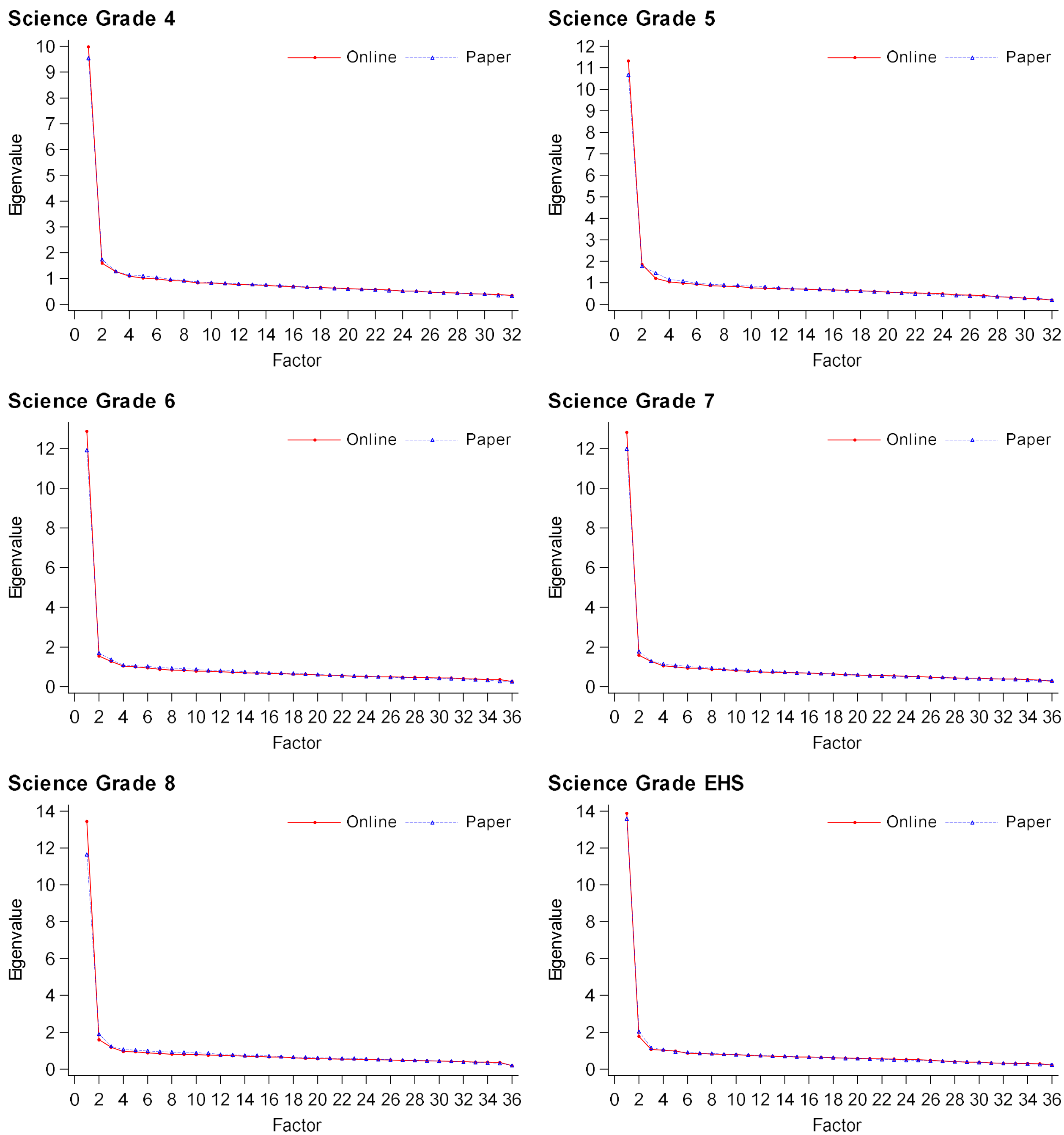


**Figure 12.1 Scree plots of ACT Aspire online and paper forms by subject and grade using data from the spring 2018 administration-continued.**

**Table 12.1. English Test Fit Statistics for One- and Two-Factor Models Using Data from the 2018 ACT Aspire Administration**

| | | Online | | Paper | |
|---|---|---|---|---|---|
| Grade | Fit Statistic | One-Factor | Two-Factor | One-Factor | Two-Factor |
| 3 | CFI | 0.959 | 0.978 | 0.940[a] | 0.968 |
| | TLI | 0.956 | 0.974 | 0.935[a] | 0.963 |
| | RMSEA | 0.029 | 0.022 | 0.038 | 0.028 |
| | SRMR | 0.041 | 0.031 | 0.057 | 0.043 |
| 4 | CFI | 0.956 | 0.985 | 0.958 | 0.981 |
| | TLI | 0.952 | 0.983 | 0.955 | 0.978 |
| | RMSEA | 0.033 | 0.020 | 0.030 | 0.021 |
| | SRMR | 0.043 | 0.028 | 0.045 | 0.035 |
| 5 | CFI | 0.955 | 0.976 | 0.959 | 0.974 |
| | TLI | 0.952 | 0.973 | 0.956 | 0.971 |
| | RMSEA | 0.030 | 0.022 | 0.026 | 0.021 |
| | SRMR | 0.040 | 0.031 | 0.045 | 0.039 |
| 6 | CFI | 0.960 | 0.981 | 0.965 | 0.976 |
| | TLI | 0.958 | 0.978 | 0.963 | 0.973 |
| | RMSEA | 0.028 | 0.020 | 0.026 | 0.022 |
| | SRMR | 0.043 | 0.031 | 0.045 | 0.038 |
| 7 | CFI | 0.981 | 0.989 | 0.980 | 0.986 |
| | TLI | 0.980 | 0.988 | 0.979 | 0.984 |
| | RMSEA | 0.020 | 0.016 | 0.018 | 0.016 |
| | SRMR | 0.032 | 0.024 | 0.042 | 0.034 |
| 8 | CFI | 0.952 | 0.969 | 0.964 | 0.978 |
| | TLI | 0.949[a] | 0.965 | 0.961 | 0.975 |
| | RMSEA | 0.030 | 0.025 | 0.025 | 0.020 |
| | SRMR | 0.043 | 0.035 | 0.048 | 0.041 |
| EHS | CFI | 0.949[a] | 0.971 | 0.953 | 0.970 |
| | TLI | 0.947[a] | 0.969 | 0.951 | 0.967 |
| | RMSEA | 0.031 | 0.024 | 0.031 | 0.025 |
| | SRMR | 0.044 | 0.031 | 0.047 | 0.038 |

[a] Indicates inadequate model-data fit.

**Table 12.2. Mathematics Test Fit Statistics for One- and Two-Factor Models Using Data from the 2018 ACT Aspire Administration**

| | | Online | | Paper | |
|---|---|---|---|---|---|
| Grade | Fit Statistic | One-Factor | Two-Factor | One-Factor | Two-Factor |
| 3 | CFI | 0.979 | 0.985 | 0.980 | 0.987 |
| | TLI | 0.978 | 0.983 | 0.979 | 0.985 |
| | RMSEA | 0.025 | 0.022 | 0.025 | 0.022 |
| | SRMR | 0.034 | 0.030 | 0.037 | 0.031 |
| 4 | CFI | 0.975 | 0.982 | 0.970 | 0.982 |
| | TLI | 0.974 | 0.980 | 0.967 | 0.980 |
| | RMSEA | 0.028 | 0.024 | 0.030 | 0.024 |
| | SRMR | 0.037 | 0.033 | 0.043 | 0.033 |
| 5 | CFI | 0.974 | 0.984 | 0.980 | 0.989 |
| | TLI | 0.972 | 0.982 | 0.978 | 0.987 |
| | RMSEA | 0.025 | 0.020 | 0.023 | 0.018 |
| | SRMR | 0.033 | 0.029 | 0.036 | 0.029 |
| 6 | CFI | 0.975 | 0.982 | 0.975 | 0.986 |
| | TLI | 0.973 | 0.980 | 0.974 | 0.984 |
| | RMSEA | 0.023 | 0.020 | 0.024 | 0.018 |
| | SRMR | 0.035 | 0.030 | 0.039 | 0.031 |
| 7 | CFI | 0.971 | 0.983 | 0.970 | 0.981 |
| | TLI | 0.969 | 0.980 | 0.968 | 0.979 |
| | RMSEA | 0.026 | 0.021 | 0.026 | 0.021 |
| | SRMR | 0.034 | 0.027 | 0.039 | 0.033 |
| 8 | CFI | 0.959 | 0.976 | 0.963 | 0.981 |
| | TLI | 0.957 | 0.974 | 0.961 | 0.979 |
| | RMSEA | 0.026 | 0.020 | 0.026 | 0.019 |
| | SRMR | 0.037 | 0.028 | 0.041 | 0.031 |
| EHS | CFI | 0.968 | 0.982 | 0.966 | 0.982 |
| | TLI | 0.967 | 0.981 | 0.964 | 0.980 |
| | RMSEA | 0.024 | 0.018 | 0.025 | 0.019 |
| | SRMR | 0.032 | 0.022 | 0.036 | 0.026 |

**Table 12.3. Reading Test Fit Statistics for One- and Two-Factor Models Using Data from the 2018 ACT Aspire Administration**

| | | Online | | Paper | |
|---|---|---|---|---|---|
| Grade | Fit Statistic | One-Factor | Two-Factor | One-Factor | Two-Factor |
| 3 | CFI | 0.951 | 0.989 | 0.915[a] | 0.985 |
| | TLI | 0.946[a] | 0.986 | 0.907[a] | 0.982 |
| | RMSEA | 0.043 | 0.022 | 0.054 | 0.024 |
| | SRMR | 0.056 | 0.026 | 0.074 | 0.033 |
| 4 | CFI | 0.974 | 0.991 | 0.963 | 0.993 |
| | TLI | 0.971 | 0.990 | 0.959 | 0.992 |
| | RMSEA | 0.034 | 0.020 | 0.036 | 0.016 |
| | SRMR | 0.040 | 0.025 | 0.048 | 0.027 |
| 5 | CFI | 0.976 | 0.991 | 0.965 | 0.986 |
| | TLI | 0.973 | 0.989 | 0.962 | 0.983 |
| | RMSEA | 0.029 | 0.018 | 0.034 | 0.023 |
| | SRMR | 0.039 | 0.025 | 0.047 | 0.033 |
| 6 | CFI | 0.972 | 0.989 | 0.955 | 0.990 |
| | TLI | 0.969 | 0.987 | 0.950 | 0.988 |
| | RMSEA | 0.035 | 0.022 | 0.042 | 0.021 |
| | SRMR | 0.041 | 0.027 | 0.055 | 0.030 |
| 7 | CFI | 0.981 | 0.992 | 0.972 | 0.992 |
| | TLI | 0.979 | 0.990 | 0.969 | 0.990 |
| | RMSEA | 0.025 | 0.017 | 0.030 | 0.017 |
| | SRMR | 0.033 | 0.022 | 0.043 | 0.029 |
| 8 | CFI | 0.967 | 0.990 | 0.924[a] | 0.986 |
| | TLI | 0.964 | 0.988 | 0.917[a] | 0.983 |
| | RMSEA | 0.039 | 0.022 | 0.053 | 0.023 |
| | SRMR | 0.044 | 0.026 | 0.068 | 0.032 |
| EHS | CFI | 0.975 | 0.986 | 0.964 | 0.984 |
| | TLI | 0.972 | 0.983 | 0.960 | 0.981 |
| | RMSEA | 0.030 | 0.023 | 0.040 | 0.027 |
| | SRMR | 0.033 | 0.025 | 0.047 | 0.031 |

[a] Indicates inadequate model-data fit.

**Table 12.4. Science Test Fit Statistics for One- and Two-Factor Models Using Data from the 2018 ACT Aspire Administration**

| | | Online | | Paper | |
|---|---|---|---|---|---|
| Grade | Fit Statistic | One-Factor | Two-Factor | One-Factor | Two-Factor |
| 3 | CFI | 0.964 | 0.980 | 0.938[a] | 0.975 |
| | TLI | 0.961 | 0.977 | 0.933[a] | 0.971 |
| | RMSEA | 0.036 | 0.027 | 0.043 | 0.028 |
| | SRMR | 0.044 | 0.033 | 0.059 | 0.039 |
| 4 | CFI | 0.961 | 0.980 | 0.954 | 0.981 |
| | TLI | 0.959 | 0.977 | 0.951 | 0.978 |
| | RMSEA | 0.032 | 0.024 | 0.032 | 0.021 |
| | SRMR | 0.041 | 0.031 | 0.048 | 0.035 |
| 5 | CFI | 0.960 | 0.979 | 0.958 | 0.979 |
| | TLI | 0.957 | 0.976 | 0.955 | 0.976 |
| | RMSEA | 0.033 | 0.024 | 0.030 | 0.022 |
| | SRMR | 0.051 | 0.033 | 0.057 | 0.046 |
| 6 | CFI | 0.972 | 0.988 | 0.965 | 0.985 |
| | TLI | 0.971 | 0.987 | 0.963 | 0.983 |
| | RMSEA | 0.029 | 0.020 | 0.029 | 0.019 |
| | SRMR | 0.038 | 0.027 | 0.046 | 0.035 |
| 7 | CFI | 0.975 | 0.985 | 0.966 | 0.986 |
| | TLI | 0.973 | 0.984 | 0.964 | 0.984 |
| | RMSEA | 0.028 | 0.022 | 0.029 | 0.019 |
| | SRMR | 0.039 | 0.030 | 0.047 | 0.035 |
| 8 | CFI | 0.974 | 0.989 | 0.958 | 0.985 |
| | TLI | 0.973 | 0.987 | 0.956 | 0.983 |
| | RMSEA | 0.030 | 0.020 | 0.032 | 0.020 |
| | SRMR | 0.036 | 0.024 | 0.049 | 0.034 |
| EHS | CFI | 0.966 | 0.986 | 0.952 | 0.982 |
| | TLI | 0.964 | 0.984 | 0.950 | 0.980 |
| | RMSEA | 0.036 | 0.024 | 0.040 | 0.025 |
| | SRMR | 0.041 | 0.024 | 0.051 | 0.031 |

[a] Indicates inadequate model-data fit.

**Table 12.5. Two-Factor Exploratory Factor Model Loadings for Two ACT Aspire Forms Identified as Showing Evidence of Two Factors Based on Analysis of Fit Statistics**

| Item | Reading Grade 3 Paper | | Reading Grade 8 Paper | |
|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 1 | Factor 2 |
| 1 | 0.208 | 0.215 | 0.517 | -0.048 |
| 2 | 0.601 | 0.078 | 0.634 | -0.023 |
| 3 | 0.381 | 0.038 | 0.439 | -0.096 |
| 4 | 0.525 | 0.136 | 0.699 | -0.073 |
| 5 | 0.478 | 0.095 | 0.703 | -0.002 |
| 6 | 0.621 | -0.010 | 0.388 | -0.033 |
| 7 | 0.482 | 0.042 | 0.560 | 0.062 |
| 8 | 0.840 | -0.065 | 0.544 | -0.118 |
| 9 | 0.726 | -0.029 | 0.748 | 0.052 |
| 10 | 0.721 | 0.045 | 0.667 | 0.141 |
| 11 | 0.802 | -0.042 | 0.450 | 0.117 |
| 12 | 0.520 | 0.056 | 0.305 | 0.156 |
| 13 | 0.466 | 0.321 | 0.355 | 0.134 |
| 14 | 0.296 | 0.423 | 0.512 | 0.222 |
| 15 | 0.226 | 0.504 | 0.534 | 0.180 |
| 16 | 0.442 | 0.427 | 0.430 | 0.166 |
| 17 | 0.191 | 0.341 | 0.124 | 0.726 |
| 18 | 0.417 | 0.425 | -0.022 | 0.683 |
| 19 | 0.017 | 0.664 | 0.009 | 0.754 |
| 20 | -0.094 | 0.724 | 0.024 | 0.794 |
| 21 | -0.093 | 0.621 | -0.013 | 0.543 |
| 22 | 0.006 | 0.646 | -0.026 | 0.805 |
| 23 | -0.009 | 0.643 | 0.059 | 0.753 |
| 24 | 0.006 | 0.603 | -0.021 | 0.573 |

# 12.5 Evidence Regarding Relationships with Conceptually Related Constructs

Often, the intended interpretations of test scores imply that the scores should be correlated with conceptually related constructs (AERA, APA, NCME, 2014). This section provides correlations of ACT Aspire test scores with three measures of conceptually related constructs: Alabama Reading and Mathematics Test plus Science (ARMT+) test scores, Partnership for Assessment of Readiness for College and Careers (PARCC) test scores, and ACT test scores.

## 12.5.1 Correlations of ACT Aspire and ARMT+ Scores

ARMT+ was designed to assess mastery of state content standards in mathematics, reading, and science. ACT Aspire is designed to measure academic achievement in English, mathematics, reading, science, and writing. While each test is built using different blueprints and specifications, both intend to measure achievement in mathematics, reading, and science.

In this study, the relationships between ARMT+ and ACT Aspire scores were examined using a sample of Alabama students taking both assessments in spring 2013 in grades 3–8 (ARMT+ science scores were only available for grades 5 and 7). Table 12.6 lists the sample sizes, means, and standard deviations for ARMT+ and ACT Aspire scale scores by subject and grade. The sample included roughly 5% to 15% of the students who took the ARMT+ in Alabama.

**Table 12.6. Correlations of ACT Aspire Scores With ARMT+ Scores**

| | | | ACT Aspire | | ARMT+ | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | Grade | N | Mean | SD | Mean | SD | $r$ | $r_{dis}$ |
| Mathematics | 3 | 9,020 | 412.2 | 3.9 | 635.3 | 39.8 | 0.60 | 0.71 |
| | 4 | 9,185 | 414.9 | 3.9 | 649.9 | 44.1 | 0.62 | 0.77 |
| | 5 | 8,188 | 416.9 | 4.8 | 676.6 | 38.2 | 0.64 | 0.79 |
| | 6 | 6,257 | 418.1 | 5.5 | 667.4 | 34.3 | 0.64 | 0.77 |
| | 7 | 5,060 | 419.1 | 6.6 | 678.3 | 42.2 | 0.72 | 0.84 |
| | 8 | 4,045 | 420.2 | 7.6 | 696.3 | 33.1 | 0.81 | 0.90 |
| Reading | 3 | 9,198 | 412.3 | 5.2 | 634.6 | 37.6 | 0.73 | 0.84 |
| | 4 | 9,249 | 414.6 | 5.6 | 651.8 | 37.7 | 0.77 | 0.88 |
| | 5 | 8,231 | 416.5 | 6.2 | 663.6 | 35.8 | 0.76 | 0.87 |
| | 6 | 6,242 | 418.5 | 6.7 | 671.9 | 35.7 | 0.74 | 0.85 |
| | 7 | 5,058 | 418.1 | 6.7 | 681.5 | 33.3 | 0.72 | 0.84 |
| | 8 | 4,306 | 420.3 | 7.2 | 681.7 | 31.5 | 0.75 | 0.85 |
| Science | 5 | 7,209 | 418.3 | 6.4 | 596.9 | 103.5 | 0.65 | 0.73 |
| | 7 | 4,702 | 418.6 | 7.4 | 563.9 | 106.9 | 0.69 | 0.76 |

*Note*. $r$ = Pearson correlation; $r_{dis}$ = disattenuated Pearson correlation.

Table 12.6 provides the Pearson correlations ($r$) and disattenuated[1] Pearson correlation ($r_{dis}$) between ARMT+ scores and ACT Aspire scores by subject and grade. Correlations ranged from .60 to .81, with higher correlations observed as grade increased for mathematics and science. These correlations indicate moderate to strong linear relationships between ARMT+ and ACT Aspire scores across subjects, as expected. Linear regression shows that 36% to 66% of the variance in scores is shared between ARMT+ and ACT Aspire. Available reliability coefficients for ARMT+ and ACT Aspire were used to calculate disattenuated correlations, which ranged from .71 to .90 and which indicate moderate to strong correlations. Linear regression shows that 50% to 81% of the variance in true scores is shared between ARMT+ and ACT Aspire.

[1] A disattenuated correlation is a correlation that has been corrected for measurement error in the variables being correlated. The disattenuated correlation is calculated as $\frac{r(x_1,x_2)}{\sqrt{rx_1 rx_2}}$ where $r(x_1,x_2)$ is the regular Pearson correlation of test scores $x_1$ and $x_2$ and $rx_1$ and $rx_2$ are the reliabilities of $x_1$ and $x_2$.

# 12.5.2 Correlations of ACT Aspire and PARCC Scores

PARCC test scores and ACT Aspire test scores measure related constructs, as both are standardized tests of the skills needed for college and career readiness (Pearson, 2017). For students in Arkansas, ACT Aspire and PARCC test scores were correlated for PARCC tests taken in spring 2015 and ACT Aspire tests taken in spring 2016.[2] PARCC ELA tests taken in grades 3–9 were paired with ACT Aspire ELA scores for grades 4–10, PARCC math tests taken in grades 3–8 were paired with ACT Aspire math tests taken in grades 4–9, and PARCC science tests taken in grades 5 and 7 were paired with ACT Aspire science tests taken in grades 6 and 8.

Table 12.7 presents the samples sizes, test score means and standard deviations, and cross-grade correlations of ACT Aspire and PARCC test scores. Across all subjects and grades, the correlations ranged from 0.71 to 0.84, and the disattenuated correlations ranged from 0.81 to 0.91. Correlations were similar across grades. On average, disattenuated correlations were highest in ELA (0.89), followed by math (0.86) and science (0.85). Test scores were highly correlated, which is evidence that indirectly supports Use 1 (to measure progress toward meeting college and career readiness content standards) and Use 2 (to measure progress toward meeting empirically-derived college and career readiness performance standards).

[2] Arkansas administered the PARCC assessments in spring 2015 and ACT Aspire beginning in spring 2016.

**Table 12.7. Correlations of ACT Aspire Scores With PARCC Scores**

| Subject | Grade pair | N | ACT Aspire Mean | ACT Aspire SD | PARCC Mean | PARCC SD | $r$ | $r_{dis}$ |
|---|---|---|---|---|---|---|---|---|
| ELA | 3–4 | 32,557 | 419.2 | 5.0 | 729.3 | 36.9 | 0.80 | 0.88 |
| | 4–5 | 32,891 | 421.5 | 5.5 | 736.2 | 31.4 | 0.81 | 0.90 |
| | 5–6 | 32,691 | 423.7 | 6.1 | 735.5 | 29.9 | 0.80 | 0.88 |
| | 6–7 | 32,810 | 423.3 | 6.3 | 736.7 | 29.0 | 0.82 | 0.89 |
| | 7–8 | 33,295 | 424.6 | 6.4 | 735.7 | 33.5 | 0.83 | 0.91 |
| | 8–9 | 32,725 | 425.1 | 7.0 | 733.9 | 34.0 | 0.83 | 0.89 |
| | 9–10 | 31,708 | 426.8 | 7.2 | 739.1 | 33.7 | 0.84 | 0.89 |
| Mathematics | 3–4 | 32,995 | 416.0 | 4.2 | 734.2 | 30.5 | 0.75 | 0.86 |
| | 4–5 | 33,137 | 417.9 | 5.2 | 729.9 | 27.9 | 0.76 | 0.89 |
| | 5–6 | 33,103 | 420.9 | 5.8 | 729.2 | 27.6 | 0.71 | 0.81 |
| | 6–7 | 32,950 | 420.5 | 6.8 | 730.5 | 27.1 | 0.76 | 0.86 |
| | 7–8 | 33,201 | 423.0 | 7.5 | 730.1 | 24.5 | 0.80 | 0.90 |
| | 8–9 | 26,816 | 421.9 | 6.5 | 721.3 | 29.7 | 0.74 | 0.82 |
| Science | 5–6 | 33,219 | 422.0 | 7.3 | 208.5 | 42.7 | 0.76 | 0.86 |
| | 7–8 | 33,554 | 423.6 | 7.8 | 181.0 | 47.1 | 0.74 | 0.83 |

*Note*. $r$ = Pearson correlation; $r_{dis}$ = disattenuated Pearson correlation.

In addition to the total group correlations (Table 12.7), correlations were examined for six student subgroups: students who are English language learners, students in special education, students who are economically disadvantaged, students who are Black/African American, students who are Hispanic, and students who are White. For each subgroup, the average sample size (across grades) is given in Table 12.8.

**Table 12.8. PARCC/ACT Aspire Correlation Sample Sizes for Subgroups, Averaged Across Grades**

| | Subject | | |
|---|---|---|---|
| Subgroup | ELA | Math | Science |
| Total | 32,668 | 32,034 | 33,387 |
| English language learners | 2,519 | 2,682 | 2,666 |
| Special education | 3,255 | 3,449 | 3,383 |
| Economically disadvantaged | 19,677 | 19,863 | 20,333 |
| Black/African American | 6,350 | 6,307 | 6,556 |
| Hispanic | 3,880 | 3,939 | 4,026 |
| White | 20,378 | 19,798 | 20,797 |

For the total group and each subgroup, PARCC/ACT Aspire cross-grade correlations are presented in Table 12.9. The simple and disattenuated correlations were averaged across grades. For each subgroup, weights were applied to make the subgroup's distribution of lower-grade scores similar to the total group's distribution.

**Table 12.9. PARCC/ACT Aspire Cross-Grade Correlations, Averaged Across Grades**

| | Subject | | | | | |
|---|---|---|---|---|---|---|
| | ELA | | Math | | Science | |
| Subgroup | $r$ | $r_{dis}$ | $r$ | $r_{dis}$ | $r$ | $r_{dis}$ |
| Total | 0.82 | 0.89 | 0.75 | 0.86 | 0.75 | 0.85 |
| English language learner | 0.79 | 0.86 | 0.72 | 0.82 | 0.72 | 0.81 |
| Special education | 0.81 | 0.88 | 0.74 | 0.84 | 0.68 | 0.77 |
| Economically disadvantaged | 0.81 | 0.88 | 0.74 | 0.84 | 0.73 | 0.82 |
| Black/African American | 0.80 | 0.87 | 0.72 | 0.82 | 0.72 | 0.81 |
| Hispanic | 0.82 | 0.89 | 0.73 | 0.83 | 0.74 | 0.83 |
| White | 0.82 | 0.89 | 0.76 | 0.86 | 0.74 | 0.84 |

*Note*. $r$ = Pearson correlation; $r_{dis}$ = disattenuated Pearson correlation.

For ELA, there is very little variation across subgroups, with disattenuated correlations ranging from 0.86 (English language learners) to 0.89 (Hispanic and White subgroups and Total). Similarly, for math, disattenuated correlations ranged from 0.82 (Black/African American and English language learner) to 0.86 (White subgroup and Total). For science, the correlation for the special education subgroup was 0.77, which was less than the Total group correlation (0.85). All of the subgroup correlations were within

0.10 of the total group's correlation. These findings suggest that ACT Aspire and PARCC scores are highly correlated for all subgroups with some minor variation in correlations across subgroups.

## 12.5.3 Correlations of ACT Aspire and 11th-Grade ACT Test Scores

ACT Aspire and the ACT both intend to measure the knowledge and skills most important for success in college and careers (ACT, 2017). ACT Aspire is intended for earlier grades but is aligned to the same college and career readiness standards as the ACT and tests the same subjects as the ACT. If ACT Aspire and the ACT measure related constructs, high correlations would be expected between the two sets of test scores. Because of variation in students' academic development from grades 3–10, we should expect the correlations of ACT Aspire scores and ACT scores to increase for later-grade ACT Aspire tests (e.g., grades 9 and 10) relative to early-grade tests. Because the ACT is a commonly used measure of college readiness, high correlations of ACT Aspire scores and 11th-grade ACT scores directly support Use 2 (to measure progress toward meeting empirically-derived college and career readiness performance standards).

Using ACT Aspire and 11th-grade ACT scores collected through spring 2020, correlations of ACT Aspire and ACT scores were examined. Because the first ACT Aspire tests were administered in spring 2013, only correlations for ACT Aspire grades 4–10 (4th-grade students in spring 2013 took the ACT as 11th-grade students in spring 2020) could be estimated.

Table 12.10 presents the samples sizes, test score means and standard deviations, and correlations of ACT Aspire and ACT scores. As expected, correlations increased with ACT Aspire grade. For example, the correlation of Composite scores was 0.88 for grades 9 and 10, 0.85 for grade 8, and 0.83 for grade 7. For grade 4, the correlations ranged from 0.58 for mathematics to 0.77 for the Composite score. Therefore, ACT Aspire scores are strong predictors of ACT scores, even for earlier grades.

The disattenuated correlations of grade 10 ACT Aspire scores and grade 11 ACT scores ranged from 0.82 for reading to 0.92 for mathematics. Because the correlation coefficients are very large, the findings indicate that ACT Aspire and the ACT measure similar constructs. The disattenuated correlations increased with ACT Aspire grade, but are still large for grade 4, ranging from 0.67 for mathematics to 0.80 for the Composite score.

**Table 12.10. Correlations of ACT Aspire Scores With 11th-Grade ACT Scores**

| | | | ACT Aspire | | ACT | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | Grade | N | Mean | SD | Mean | SD | $r$ | $r_{dis}$ |
| English | 4 | 6,867 | 419.9 | 6.0 | 19.2 | 6.7 | 0.66 | 0.76 |
| | 5 | 18,333 | 422.7 | 6.8 | 18.9 | 6.7 | 0.69 | 0.81 |
| | 6 | 35,840 | 424.4 | 7.8 | 18.5 | 6.6 | 0.71 | 0.82 |
| | 7 | 80,716 | 426.9 | 8.4 | 18.6 | 6.6 | 0.73 | 0.84 |
| | 8 | 140,730 | 428.1 | 8.7 | 18.7 | 6.6 | 0.77 | 0.88 |
| | 9 | 368,328 | 429.4 | 9.8 | 19.3 | 6.5 | 0.81 | 0.90 |
| | 10 | 554,191 | 431.3 | 10.3 | 19.2 | 6.4 | 0.82 | 0.91 |
| Mathematics | 4 | 7,259 | 415.2 | 3.9 | 18.7 | 5.0 | 0.58 | 0.67 |
| | 5 | 44,668 | 417.6 | 5.0 | 18.1 | 4.7 | 0.63 | 0.75 |
| | 6 | 89,152 | 420.1 | 5.9 | 18.0 | 4.7 | 0.68 | 0.79 |
| | 7 | 160,602 | 420.3 | 6.9 | 18.1 | 4.6 | 0.74 | 0.85 |
| | 8 | 248,774 | 423.0 | 7.8 | 18.2 | 4.7 | 0.78 | 0.89 |
| | 9 | 370,601 | 426.3 | 8.4 | 19.8 | 5.2 | 0.81 | 0.91 |
| | 10 | 556,484 | 427.4 | 9.1 | 19.5 | 5.1 | 0.82 | 0.92 |
| Reading | 4 | 7,216 | 415.1 | 5.6 | 19.7 | 6.4 | 0.67 | 0.78 |
| | 5 | 44,652 | 417.7 | 5.9 | 19.1 | 6.3 | 0.67 | 0.79 |
| | 6 | 88,992 | 420.0 | 6.4 | 19.0 | 6.3 | 0.67 | 0.78 |
| | 7 | 160,259 | 420.4 | 6.2 | 19.0 | 6.3 | 0.68 | 0.80 |
| | 8 | 248,379 | 423.1 | 6.8 | 19.2 | 6.3 | 0.68 | 0.81 |
| | 9 | 369,983 | 423.2 | 7.7 | 20.3 | 6.4 | 0.71 | 0.84 |
| | 10 | 555,931 | 424.1 | 7.8 | 20.1 | 6.3 | 0.71 | 0.82 |
| Science | 4 | 6,618 | 417.2 | 6.4 | 19.5 | 5.4 | 0.62 | 0.73 |
| | 5 | 16,017 | 419.7 | 6.1 | 19.0 | 5.3 | 0.64 | 0.75 |
| | 6 | 36,531 | 421.3 | 6.8 | 19.0 | 5.4 | 0.67 | 0.78 |
| | 7 | 124,374 | 422.2 | 7.4 | 18.8 | 5.3 | 0.70 | 0.82 |
| | 8 | 149,345 | 424.6 | 7.7 | 19.2 | 5.4 | 0.72 | 0.83 |
| | 9 | 367,254 | 426.5 | 8.6 | 20.3 | 5.4 | 0.74 | 0.85 |
| | 10 | 552,686 | 427.7 | 9.1 | 20.1 | 5.3 | 0.75 | 0.86 |

*Note*. $r$ = Pearson correlation; $r_{dis}$ = disattenuated Pearson correlation.

**Table 12.10. Correlations of ACT Aspire Scores With 11th-Grade ACT Scores—continued**

| | | | ACT Aspire | | ACT | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | Grade | N | Mean | SD | Mean | SD | $r$ | $r_{dis}$ |
| Composite | 4 | 5,971 | 417.0 | 4.7 | 19.3 | 5.4 | 0.77 | 0.80 |
| | 5 | 12,074 | 419.6 | 5.2 | 19.1 | 5.3 | 0.79 | 0.82 |
| | 6 | 29,243 | 421.6 | 5.9 | 18.9 | 5.4 | 0.81 | 0.84 |
| | 7 | 72,132 | 422.8 | 6.5 | 18.9 | 5.3 | 0.83 | 0.86 |
| | 8 | 132,051 | 425.0 | 7.0 | 19.1 | 5.3 | 0.85 | 0.88 |
| | 9 | 361,450 | 426.5 | 7.7 | 20.0 | 5.4 | 0.88 | 0.91 |
| | 10 | 544,886 | 427.8 | 8.2 | 19.8 | 5.3 | 0.88 | 0.91 |
| ELA | 4 | 652 | 419.6 | 5.1 | 17.4 | 5.6 | 0.69 | 0.75 |
| | 5 | 9,148 | 421.9 | 5.4 | 17.5 | 5.6 | 0.73 | 0.80 |
| | 6 | 24,530 | 423.4 | 5.9 | 17.1 | 5.6 | 0.75 | 0.82 |
| | 7 | 44,648 | 423.5 | 6.0 | 16.9 | 5.5 | 0.78 | 0.86 |
| | 8 | 67,895 | 425.1 | 6.1 | 17.1 | 5.6 | 0.80 | 0.88 |
| | 9 | 258,430 | 426.7 | 7.0 | 18.8 | 5.6 | 0.83 | 0.90 |
| | 10 | 406,040 | 427.7 | 7.3 | 18.4 | 5.6 | 0.84 | 0.90 |
| STEM | 4 | 6,244 | 416.4 | 4.7 | 19.3 | 5.0 | 0.69 | 0.75 |
| | 5 | 15,517 | 418.8 | 5.0 | 18.8 | 4.8 | 0.72 | 0.79 |
| | 6 | 36,285 | 421.1 | 5.8 | 18.8 | 4.8 | 0.74 | 0.80 |
| | 7 | 123,569 | 421.6 | 6.7 | 18.7 | 4.7 | 0.79 | 0.86 |
| | 8 | 148,730 | 424.3 | 7.3 | 19.0 | 4.8 | 0.81 | 0.87 |
| | 9 | 365,339 | 426.7 | 8.0 | 20.3 | 5.0 | 0.84 | 0.91 |
| | 10 | 549,563 | 427.8 | 8.6 | 20.0 | 4.9 | 0.85 | 0.91 |

*Note*. $r$ = Pearson correlation; $r_{dis}$ = disattenuated Pearson correlation.

# 12.6 Evidence Regarding Relationships with Criteria

Intended uses of test scores imply that the scores should be predictive of criterion variables that are hypothetically related to the construct measured by the test. In this section, we examine how well ACT Aspire scores predict performance in high school courses, as well as performance on Advanced Placement (AP) exams.

## 12.6.1 Prediction of High School Course Grades

High school courses help students meet academic standards and prepare for college and careers. Thus, by measuring academic standards important for college and career readiness (Use 1) and readiness for college and careers (Use 2), ACT Aspire test scores should predict high school course grades—including standard, career-focused, AP, and dual-enrollment courses. By examining AP and dual-enrollment courses, college readiness is directly addressed. Similarly, by examining career-focused courses, career readiness is directly addressed. Students who are struggling in high school courses are candidates for extra academic support. ACT Aspire test scores, if predictive of performance in high school courses, can help identify students in need of support early. Examining how well ACT Aspire scores predict high school grades provides support for Use 3 (to provide instructionally actionable information to educators).

ACT Aspire scores from grades 8–10 are linked to performance in high school courses, using data provided by the Arkansas Department of Education. ACT Aspire scores from spring 2016 and spring 2017 are linked to performance in the next year's courses (e.g., academic years 2016–2017 and 2017–2018). Analyses were conducted for 48 courses, including 19 standard courses, nine career-focused courses, 10 AP courses, and 10 dual-enrollment courses. For English and social science (social studies) courses, the ACT Aspire ELA score was used as the predictor. For math and science courses, the ACT Aspire math and science scores were used, respectively. For career-focused courses, the ACT Aspire Composite score was used. Analyses were also conducted by student subgroup (Total group, English language learners, special education, economically disadvantaged, Black/African American, Hispanic, and White).

Student grades were categorized as A, B, C, D, or F. For course grade data provided on a numeric scale (0–100), grades were coded as A = ≥ 90, B = 80–89, C = 70–79, D = 60–69, and F < 60 or withdrawal from course. Three dichotomous grade outcomes were defined, representing different levels of success: A, B or higher, and C or higher. In this chapter, results for the B or higher criterion are summarized. Hierarchical logistic regression was used to relate the ACT Aspire test scores to the course success outcome. The model accommodates school-specific intercepts, which is important because grading standards vary across schools. ACT Aspire test scores were standardized (Mean = 0, SD = 1) for the population of Arkansas examinees at the grade before the course was usually taken. Table 12.11 presents the sample sizes, logistic regression slope estimates, and accuracy rates for 27 of the 48 courses. Results for all 48 courses are available in a separate report (Allen, Radunzel, & Li, 2019).

**Table 12.11. Logistic Regression Slopes and Accuracy Rates for Predicting B or Higher Grades in High School Courses**

| Course | Grades | Test Score (predictor) | N | Slope | | INS Accuracy rate |
|---|---|---|---|---|---|---|
| | | | | EST | SE | |
| English 9 | 8–9 | ELA | 61,575 | 1.47 | 0.01 | 0.75 |
| English 10 | 9–10 | ELA | 59,460 | 1.40 | 0.01 | 0.74 |
| English 11 | 10–11 | ELA | 39,232 | 1.16 | 0.02 | 0.71 |
| Algebra I | 8–9 | Math | 46,635 | 1.44 | 0.02 | 0.69 |
| Geometry | 9–10 | Math | 58,471 | 1.52 | 0.01 | 0.74 |
| Algebra II | 10–11 | Math | 51,459 | 1.24 | 0.01 | 0.71 |
| Physical Science | 8–9 | Science | 60,569 | 1.37 | 0.01 | 0.74 |
| Biology | 9–10 | Science | 62,629 | 1.29 | 0.01 | 0.72 |
| Chemistry | 10–11 | Science | 40,715 | 1.19 | 0.02 | 0.71 |
| Civics | 8–9 | ELA | 58,940 | 1.24 | 0.01 | 0.74 |
| World History | 9–10 | ELA | 50,440 | 1.24 | 0.01 | 0.73 |
| U.S. History | 10–11 | ELA | 45,650 | 1.16 | 0.02 | 0.71 |
| CF: Survey of Agriculture Systems | 8–9 | Composite | 12,707 | 1.18 | 0.03 | 0.76 |
| CF: Child Development | 9–10 | Composite | 8,722 | 1.38 | 0.04 | 0.74 |
| CF: Financial Literacy | 10–11 | Composite | 5,481 | 1.41 | 0.05 | 0.77 |
| AP English Lang. & Composition | 10–11 | ELA | 14,874 | 1.60 | 0.04 | 0.76 |
| AP Calculus AB | 10–11 | Math | 1,011 | 1.39 | 0.16 | 0.73 |
| AP Biology | 10–11 | Science | 3,197 | 1.45 | 0.08 | 0.74 |
| AP Human Geography | 8–9 | ELA | 1,566 | 1.87 | 0.12 | 0.69 |
| AP World History | 9–10 | ELA | 9,052 | 1.69 | 0.05 | 0.74 |
| AP Psychology | 10–11 | ELA | 1,662 | 1.79 | 0.13 | 0.78 |
| DE: Oral Communication | 10–11 | ELA | 1,739 | 1.07 | 0.09 | 0.69 |
| DE: College Algebra | 10–11 | Math | 1,088 | 1.16 | 0.14 | 0.69 |
| DE: Biology | 9–10 | Science | 568 | 1.21 | 0.13 | 0.71 |
| DE: Anatomy & Physiology | 10–11 | Science | 330 | 1.18 | 0.20 | 0.70 |
| DE: World History | 9–10 | ELA | 735 | 1.47 | 0.13 | 0.74 |
| DE: U.S. History | 10–11 | ELA | 1,084 | 0.87 | 0.13 | 0.66 |

*Note*. EST = slope estimate; SE = standard error of slope estimate; INS = In Need of Support; AP = Advanced Placement; CF = career focused; DE = dual enrollment.

The logistic regression slopes represent the change in the log-odds of success, associated with a standard deviation increase in ACT Aspire test score. For example, for English 9, the slope estimate is 1.47. This means that the odds of earning a B or higher increase by a factor of 4.3 ($e^{1.47}$) for each standard deviation increase in ACT Aspire ELA score.

To evaluate how well ACT Aspire scores predict performance in high school courses, points of reference for the predictive strength of established measures are needed. Because ACT scores have been used to predict college success for decades with well-documented validity evidence (ACT, 2017), we use results from ACT's College Readiness Benchmarks research as points of reference (Table 12.12) (Allen, 2013; Radunzel, Westrick, Bassiri, & Li, 2017). The logistic regression slope values presented in Table 12.12 were calculated using the same methods (hierarchical logistic regression) as used for this study. These slopes are referred to as *ACT reference slopes*.

**Table 12.12. ACT Reference Slopes: Logistic Regression Slopes of ACT Scores for Predicting B or Higher Grades in College Courses**

| Subject | College course(s) | Slope |
|---|---|---|
| ELA | English composition | 0.90 |
| | Social science | 1.23 |
| Math | College algebra | 1.12 |
| Science | Biology | 1.15 |

Across the 27 courses presented in Table 12.11, the logistic regression slope ranged from 0.87 (for dual-enrollment U.S. History courses) to 1.87 (for AP Human Geography). For all courses but one, the logistic regression slopes exceeded each B or higher ACT reference slope. Thus, the relationship between ACT Aspire test scores and high school course performance is generally stronger than the relationship between ACT test scores and college course performance.

Using all 48 courses, the average logistic regression slopes for the B or higher criterion were compared across student subgroups (Table 12.13). For each subgroup, weights were applied to make the subgroup's distribution of test scores similar to the total group's distribution.[1] For all subgroups, the mean slope exceeded each ACT reference slope. Some variation was found across subgroups in the predictive strength of ACT Aspire test scores: Mean slopes were largest for the Black/African American and White subgroups; slopes were smallest for the special education and English language learner subgroups. These results suggest that the predictive strength of ACT Aspire scores varies by subgroup, but that ACT Aspire scores are strong predictors of success in high school courses for all subgroups.

[1] The weights correct for artificial differences across groups in mean slopes that can be attributed to the distribution of test scores.

**Table 12.13. Average Predictive Strength (Logistic Regression Slopes), by Subgroup**

| Subgroup | N courses | Average slope for predicting B or higher grades |
|---|---|---|
| Total | 48 | 1.30 |
| English language learners | 29 | 1.05 |
| Special education | 26 | 0.98 |
| Economically disadvantaged | 48 | 1.21 |
| Black/African American | 36 | 1.31 |
| Hispanic | 36 | 1.20 |
| White | 48 | 1.30 |

For each content area, course success rates can also be examined by ACT Aspire Readiness Levels (In Need of Support, Close, Ready, and Exceeding). B or higher success rates, averaged across core subject courses, are presented in Figure 12.2. As expected, success rates increase significantly with readiness level. Students at the In Need of Support level were the least likely to earn B or higher grades, with success rates ranging from 28% for math courses to 43% for social studies courses.

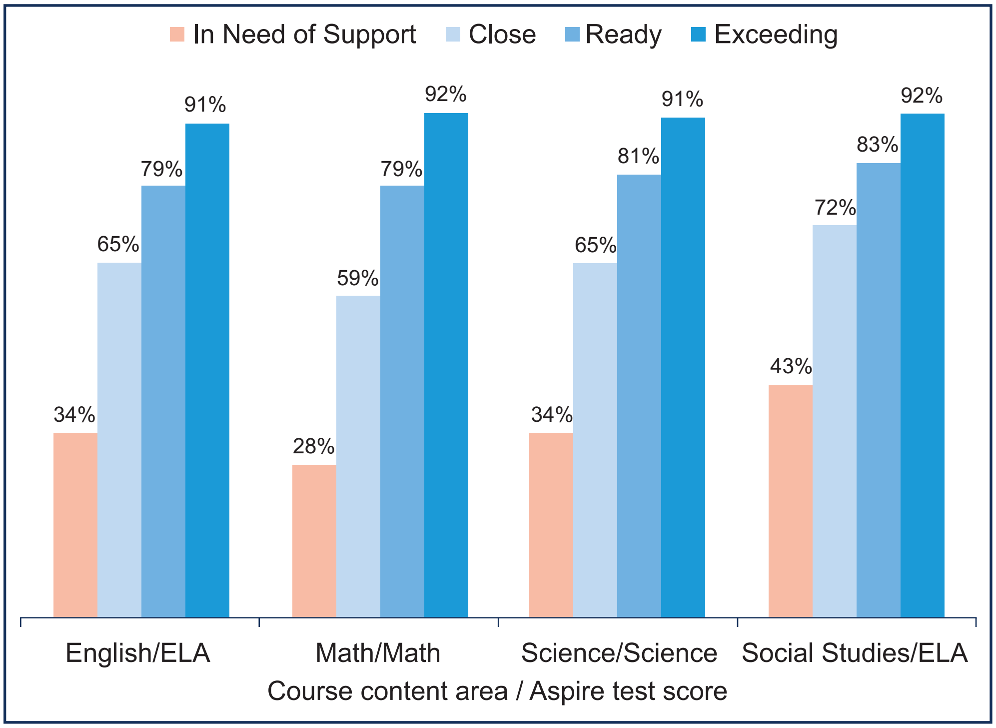


**Figure 12.2. B or higher success rates, by ACT Aspire Readiness Level, averaged across core subject courses.**

Comparing ACT Aspire Readiness Levels and course success outcomes enable calculations of accuracy rates and other measures of predictive strength. Table 12.14 shows the cross-tabulation of ACT Aspire Readiness Level and B or higher outcomes, averaged across courses. The table gives the percentage of students with each combination of readiness level and outcome, as well as margin percentages. Classifications of In Need of Support are considered accurate if a student is not successful in a course (i.e., earns a C or lower), and classifications of other readiness levels are considered accurate if a student is successful in a course (i.e., earns a B or higher) (see cells shaded in gray). Table 12.11 presents the In Need of Support accuracy rates for the 27 courses shown. Across all math courses, the average accuracy rate for In Need of Support classifications was 71%. Similarly, the average accuracy rates were 74% for English courses, 72% for science courses, 73% for social studies courses, and 75% for career-focused courses.

**Table 12.14. Comparing ACT Aspire Readiness Level and B or Higher Course Outcome, Averaged Over Courses**

| Course content area/Aspire test score | Readiness Level[a] | Course outcome: B or higher | Course outcome: C or lower | Total |
|---|---|---|---|---|
| English/ELA | In Need of Support | 12.9% | 25.4% | 38.3% |
| | Close | 13.4% | 7.2% | 20.7% |
| | Ready | 15.9% | 4.2% | 20.1% |
| | Exceeding | 18.9% | 2.0% | 20.9% |
| | Total | 61.2% | 38.8% | 100.0% |
| Math/Math | In Need of Support | 13.2% | 31.4% | 44.6% |
| | Close | 14.7% | 10.7% | 25.4% |
| | Ready | 13.3% | 3.9% | 17.2% |
| | Exceeding | 11.7% | 1.1% | 12.8% |
| | Total | 52.9% | 47.1% | 100.0% |
| Science/Science | In Need of Support | 15.1% | 29.1% | 44.2% |
| | Close | 14.5% | 7.9% | 22.3% |
| | Ready | 16.4% | 3.9% | 20.3% |
| | Exceeding | 12.1% | 1.1% | 13.2% |
| | Total | 58.0% | 42.0% | 100.0% |
| Social studies/ELA | In Need of Support | 16.3% | 21.9% | 38.2% |
| | Close | 14.8% | 5.9% | 20.7% |
| | Ready | 16.8% | 3.4% | 20.2% |
| | Exceeding | 19.3% | 1.6% | 20.9% |
| | Total | 67.2% | 32.8% | 100.0% |
| Career-focused/Composite | Bronze or below | 18.3% | 13.1% | 31.4% |
| | Silver | 29.3% | 5.1% | 34.4% |
| | Gold | 21.7% | 1.2% | 22.9% |
| | Platinum | 11.1% | 0.2% | 11.3% |
| | Total | 80.4% | 19.6% | 100.0% |

[a] For the career-focused courses, career readiness levels are based on the Progress Toward Career Readiness indicator (Allen, 2018) instead of ACT Readiness Levels.

## 12.6.2 Prediction of Success on AP Exams

If ACT Aspire test scores predict AP exam scores, there is additional evidence that ACT Aspire measures college readiness. Such evidence would directly support another use of ACT Aspire scores: to inform gauge students' readiness for advanced high school coursework (Use 5).

For this study, ACT Aspire scores from grades 8–10 were linked to performance on AP exams, using data provided by the Arkansas Department of Education. Hierarchical logistic regression was used to relate ACT Aspire scores to success on the AP exam, which is defined as earning a 3 ("qualified for doing the work of an introductory-level college course") or higher.

Analyses were conducted for different AP courses and student subgroups. There were 10 AP courses and six student subgroups (English language learners, special education, economically disadvantaged, Black/African American, Hispanic, and White). For AP exams associated with English and social studies courses, the ACT Aspire ELA score was used as the predictor. For AP exams in math and science, the ACT Aspire math and science scores were used, respectively.

With 10 courses and seven groups (six subgroups and total group), there are 70 possible conditions. We restricted the analysis to conditions with a sample size of at least 100, resulting in 45 conditions for analysis. ACT Aspire scores were standardized (Mean = 0, SD = 1) for the population of Arkansas examinees at the grade before the AP exam was usually taken.

Table 12.15 presents the sample sizes, logistic regression slope estimates, and accuracy rates for the 10 AP courses. The logistic regression slopes represent the change in the log-odds of success, which is associated with a standard deviation increase in ACT Aspire test score. For example, for AP Statistics, the slope estimate was 3.05. This means that the odds of earning a 3 or higher on the AP Statistics exam increase by a factor of 21.1 ($e^{3.05}$) for each standard deviation increase in ACT Aspire math score. Across the 10 courses, the slope estimates range from 2.15 (Human Geography) to 3.83 (English Literature and Composition). Because the slopes are much larger than the ACT reference slopes (Table 12.12), the findings suggest that ACT Aspire scores are very strong predictors of success on AP exams.

**Table 12.15. Logistic Regression Slopes and Accuracy Rates for Predicting Success (Score of 3 or Higher) on AP Exams**

| AP exam | Grade pair | Test Score (predictor) | N | Slope | | Exceeding accuracy rate |
|---|---|---|---|---|---|---|
| | | | | EST | SE | |
| English Lang. & Comp. | 10–11 | ELA | 13,373 | 3.47 | 0.07 | 0.86 |
| English Lit. & Comp. | 10–11 | ELA | 1,923 | 3.83 | 0.22 | 0.85 |
| Calculus AB | 10–11 | Math | 802 | 2.23 | 0.20 | 0.92 |
| Statistics | 10–11 | Math | 813 | 3.05 | 0.25 | 0.94 |
| Biology | 10–11 | Science | 2,841 | 2.93 | 0.13 | 0.91 |
| Chemistry | 10–11 | Science | 1,025 | 2.90 | 0.24 | 0.90 |
| Physics | 10–11 | Science | 1,657 | 2.81 | 0.20 | 0.90 |
| Human Geography | 8–9 | ELA | 1,347 | 2.15 | 0.14 | 0.84 |
| World History | 9–10 | ELA | 7,873 | 2.39 | 0.07 | 0.84 |
| Psychology | 10–11 | ELA | 1,459 | 2.72 | 0.16 | 0.86 |

*Note*. EST = slope estimate; SE = standard error.

The probability of success on an AP test can be graphed by ACT Aspire score to show the predictive strength of ACT Aspire. For example, Figure 12.3 shows the probability of success on the AP English Language and Composition exam as a function of ACT Aspire ELA score. The probability of success is very low for ACT Aspire ELA scores below 430 but then increases drastically for scores above 430. Students with ELA scores of 438 and higher have more than a 0.50 probability of succeeding on the AP exam, and students with ELA scores of 443 and higher have more than a 0.90 probability of succeeding on the AP exam.

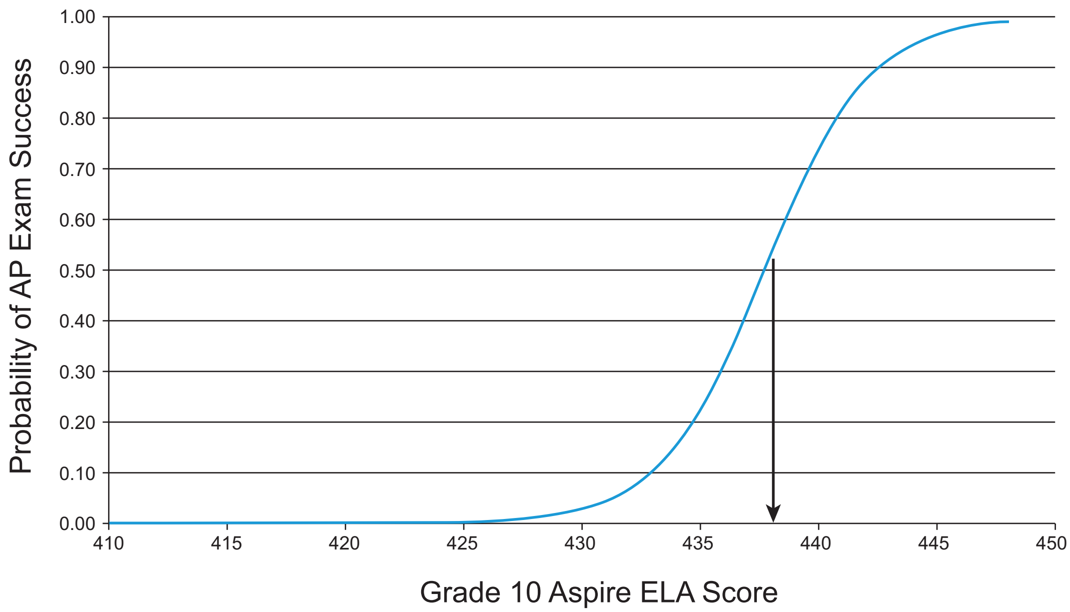


**Figure 12.3. Probability of success (score of 3 or higher) on AP English Language and Composition Exam by ACT Aspire ELA score.**

The average logistic regression slopes for AP exam success were compared across student subgroups (Table 12.16). Results are not provided for the special education subgroup because no AP exams met the sample-size requirement of 100 or more students. For all other subgroups, the mean slopes far exceed all ACT reference slopes (Table 12.12). No significant differences in predictive strength across subgroups were found suggesting that, across student subgroups, ACT Aspire test scores are very strong predictors of success on AP exams.

**Table 12.16. Predictive Strength (Logistic Regression Slopes) for AP Exam Success (Score of 3 or Higher), by Subgroup**

| | | Logistic regression slope estimates | | |
|---|---|---|---|---|
| Subgroup | N courses | Min | Mean | Max |
| Total | 10 | 2.15 | 3.01 | 3.83 |
| English language learner | 2 | 1.96 | 3.34 | 5.33 |
| Economically disadvantaged | 10 | 2.20 | 3.01 | 3.94 |
| Black/African American | 6 | 2.19 | 3.33 | 5.14 |
| Hispanic | 7 | 2.34 | 2.89 | 3.45 |
| White | 10 | 2.04 | 2.95 | 3.82 |

For each AP exam, course success rates can also be examined by ACT Aspire Readiness Levels (In Need of Support, Close, Ready, and Exceeding). Exam success rates are presented in Figure 12.4. As expected, success rates increase significantly with readiness level. Results are not shown for the In Need of Support level because very few students at that level took AP exams. Students scoring at the Exceeding level had reasonably high rates of success on AP exams, ranging from 25% for Physics to 66% for Biology and Psychology. Students at the Close level had very low rates of success on AP exams. The success rates for students scoring at the Ready level range from 3% (English Literature and Composition) to 27% (Psychology).

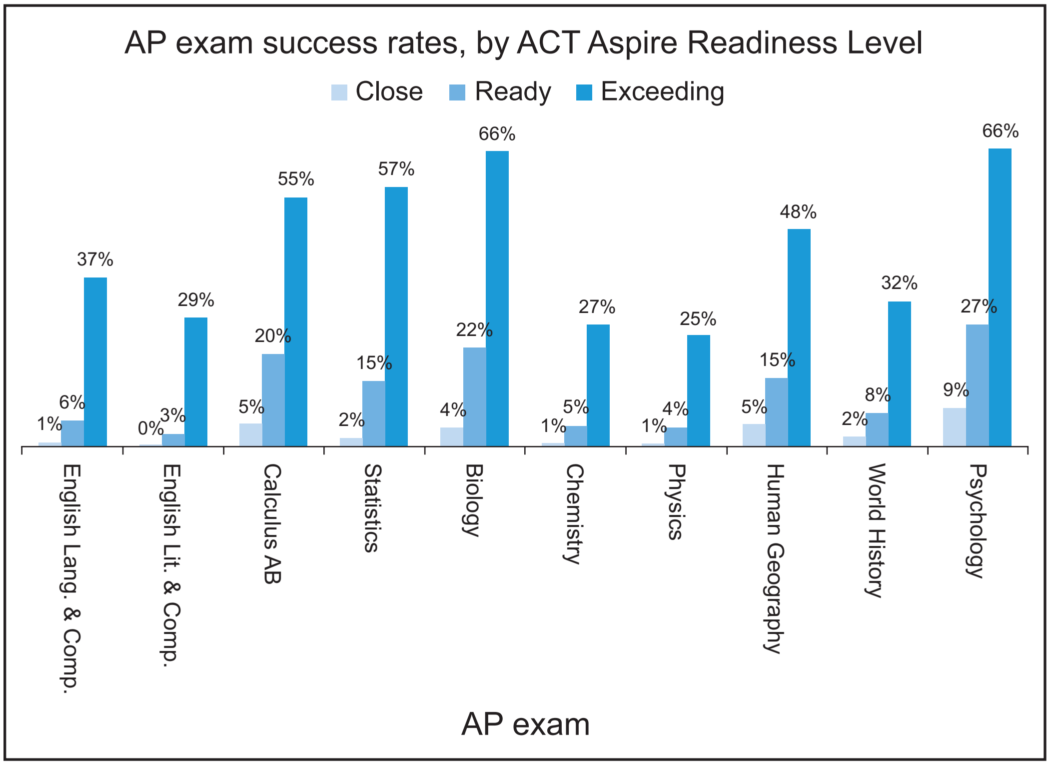


**Figure 12.4. AP exam success rates, by ACT Aspire Readiness Level.**

## 12.6.3 ACT Aspire Scores Associated with AP Exam Success

The study documented in section 12.6.2 found that ACT Aspire scores are good predictors of success on AP exams. Another recent study provided further evidence that ACT Aspire scores are good predictors of success on AP exams, and also estimated the ACT Aspire cut scores associated with AP exam success (Radunzel & Allen, 2020). Data for the study was available for 49,220 students from 318 high schools who had taken at least one AP exam in May of 2015 through May of 2019 and had previously taken ACT Aspire, PreACT, or the ACT test. A concordance of ACT Aspire scores with PreACT/ACT scores was used to combine data across assessments. Full details of the study are documented in an ACT research report (see Radunzel & Allen, 2020).

The study found that ACT Aspire and PreACT/ACT scores are positively related to AP exam scores and are good predictors of success, as measured by receiving a score of 3 or higher and 4 or higher on the corresponding AP exam. The prediction was strengthened by using combined ACT Aspire scores that were aligned to the content of the AP courses. The sum of the English and Reading scores (denoted E+R) and English Language Arts (ELA) score (average of the English, reading, and writing scores) were used for ELA-related AP courses and the STEM score (average of the math and science scores) was used for STEM-related courses. As a result, the recommended linkages to AP exam success were developed in relation to content-relevant scores for most courses (shown in Table 12.15).

For each course and outcome, two cut scores are provided – one for fall and one for spring testing depending on when students take ACT Aspire. For example, the first row of results within the table indicates that students who tested in the fall and achieved an ACT Aspire E+R score of 867 or higher are likely academically ready to take AP English Language and Composition in the subsequent academic year as they have a 50% or greater chance of earning a 3 or higher on the corresponding AP exam. Those with an ACT Aspire E+R score of 879 or higher have a 50% or greater chance of earning a 4 or higher score. The AP-ready cut scores derived from spring testing in grade 9 or 10 are slightly higher at 870 (for 3 or higher) and 881 (for 4 or higher) to account for the reduced time between ACT Aspire testing and taking the AP exam. Table 12.15 also reports the correlations (r) between test scores (ACT Aspire, PreACT, or ACT) and AP exam scores.

For a holistic view of student readiness, we recommend using ACT Aspire scores in combination with other readiness measures (e.g., high school coursework taken, high school grades, motivation, interest) in determining who is likely ready for AP courses.

**Table 12.17. ACT Aspire Scores Associated with Approximately a 50% Chance of Success on AP Exams**

AP Exams

| | | ACT Aspire | | 3 or higher | | 4 or higher | |
|---|---|---|---|---|---|---|---|
| AP course | N | score | *r* | Fall | Spring | Fall | Spring |
| ELA-related | | | | | | | |
| English Lang. and Composition | 22,044 | E+R | .71 | 867 | 870 | 879 | 881 |
| | | ELA | .72 | 433 | 434 | 438 | 438 |
| English Lit. and Composition | 21,227 | E+R | .73 | 875 | 877 | 884 | 884 |
| | | ELA | .72 | 436 | 437 | 440 | 440 |
| European History | 1,025 | E+R | .66 | 870 | 875 | 881 | 883 |
| | | ELA | .66 | 434 | 436 | 438 | 440 |
| Human Geography | 3,245 | E+R | .57 | 865 | 865 | 878 | 878 |
| | | ELA | .56 | 432 | 432 | 437 | 437 |
| Psychology | 6,813 | E+R | .65 | 862 | 867 | 872 | 875 |
| | | ELA | .64 | 432 | 433 | 435 | 436 |
| US Govt. and Politics | 5,050 | E+R | .60 | 873 | 876 | 882 | 884 |
| | | ELA | .60 | 435 | 436 | 439 | 440 |
| US History | 15,669 | E+R | .61 | 869 | 873 | 880 | 881 |
| | | ELA | .61 | 434 | 435 | 438 | 438 |
| World History | 8,675 | E+R | .62 | 862 | 868 | 877 | 880 |
| | | ELA | .62 | 432 | 433 | 437 | 438 |
| STEM-related | | | | | | | |
| Biology | 8,478 | STEM | .73 | 435 | 436 | 440 | 442 |
| Calculus AB* | 3,983 | STEM | .61 | 439 | 439 | 442 | 442 |
| Chemistry | 5,157 | STEM | .66 | 438 | 439 | 442 | 443 |
| Computer Science A | 1,091 | STEM | .67 | 438 | 438 | 442 | 442 |
| Environmental Science | 3,643 | STEM | .71 | 436 | 438 | 439 | 440 |
| Macroeconomics | 978 | STEM | .60 | 438 | 440 | 442 | 442 |
| Microeconomics | 911 | STEM | .61 | 436 | 439 | 439 | 442 |
| Physics 1** | 3,628 | STEM | .69 | 442 | 442 | 444 | 444 |
| Physics C: E and M | 100 | STEM | .62 | 440 | 442 | 442 | 444 |
| Physics C: Mechanics | 413 | STEM | .59 | 439 | 439 | 442 | 442 |
| Statistics | 6,002 | STEM | .72 | 436 | 438 | 442 | 442 |
| Other | | | | | | | |
| Art History | 734 | Comp. | .50 | 435 | 435 | 441 | 441 |
| Music Theory | 1,078 | Comp. | .56 | 433 | 435 | 438 | 440 |
| PSAT/SAT-derived | | | | | | | |
| Comparative Govt. and Politics | -- | Comp. | -- | 435 | 435 | 438 | 438 |
| Computer Science Principles | -- | Comp. | -- | 428 | 428 | 438 | 438 |

Note. E+R = English + Reading score. Comp. = Composite score.

*Cut scores are not reported for AP Calculus BC. As recommended by College Board as part of AP Potential, students who meet the AP Calculus AB cut scores and perform well in courses leading up to Calculus may consider taking AP Calculus BC.
**Cut scores are not reported for AP Physics 2. As recommended by College Board as part of AP Potential, students who meet the AP Physics 1 cut scores and perform well in prerequisite courses for AP Physics 2 may consider taking AP Physics 2.

# 12.7 Evidence of Consequences of Tests

Consequences of testing include those from (a) interpretations and uses of test scores intended by the test developer, (b) claims made about the test that are not directly based on test score, and (c) unintended consequences (AERA, APA, & NCME, 2014). These consequences cannot always be anticipated, and ACT continually seeks evidence of both positive and negative consequences. In this section, we briefly discuss some examples of unintended consequences that could result from ACT Aspire testing.

Academic achievement, which ACT Aspire measures, is not the only characteristic important for readiness for college and careers. Other characteristics, such as behaviors, attitudes, and education- and career-planning skills also contribute to student success (Mattern, Burrus, Camara, O'Connor, Hansen, Gambrell, Casillas, & Bobek, 2014). An unintended consequence of using ACT Aspire scores to indicate readiness for college and career may be to over-emphasize the cognitive contribution and under-emphasize important, but frequently difficult to measure, noncognitive contributions. An over-emphasis on ACT Aspire test scores could lead to fewer resources available to help students develop noncognitive skills.

Providing instructionally actionable information to educators may have unintended consequences. If used in an extreme way, such information could lead to what is often referred to as "teaching to the test." ACT Aspire is a standards-based Summative Assessment of academic achievement that is built to particular specifications. However, the items that appear on ACT Aspire tests are a sampling of content, as defined by the test specifications, from the broad content domain. There is a risk that if the information provided to educators is too specific, educators may ignore subject matter that is less emphasized by the ACT Aspire test specifications.

It is often difficult to adequately identify and evaluate consequences because the necessary data are not always immediately available. However, the entire testing cycle, from determining the content domains to evaluating the results from test administrations has been established to reduce or eliminate problematic sources of unintended negative consequences. Descriptions of the test cycle are included in various chapters of this manual.

# 12.8 Summary

This chapter summarized evidence that can inform validity arguments related to using and interpreting ACT Aspire scores. The focus was on how six sources of validity evidence support two principal and four secondary uses of ACT Aspire test scores. Work on validating ACT Aspire score interpretations for proposed uses will be ongoing as the educational landscape and uses of ACT Aspire scores evolve.

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# Chapter 13

# Fairness

The chapter contains evidence to address the fairness of ACT Aspire assessments. Four aspects of fairness are considered: fairness during the testing process, fairness in test accessibility, fairness in score interpretations for intended uses, and differential item functioning.

## 13.1 Overview

Fairness is a fundamental consideration when interpreting test scores for particular uses. However, the term *fairness* is used in many ways and does not have a single technical definition. In addition, a comprehensive evaluation of fairness would consider all goals implied by a test, which could extend beyond the interpretations of scores for particular uses. Such goals could include social goals and legal requirements (AERA, APA, & NCME, 2014; Camilli, 2006).

This chapter adopts the perspective on fairness included in *The Standards for Educational and Psychological Testing* (AERA et al., 2014), which focuses on tests, testing, and using tests when evaluating fairness. Four aspects of fairness are considered: fairness in treatment during the testing process, fairness in access to the construct(s) as measured, fairness as validity of individual test score interpretations for the intended uses, and fairness as lack of measurement bias.

Like validity, evaluating fairness is ongoing; evidence is collected and reported as it becomes available. Evidence of fairness of the ACT Aspire assessments is not limited to this chapter and can be found in other chapters of this manual and other ACT Aspire documentation, although we have attempted to present or reference relevant evidence for evaluating fairness here.

## 13.2 Fairness During the Testing Process

Fairness during the testing process refers to testing students in a way that best shows what they know and can do. In other words, the entire testing process, from the test design to scoring, helps students to perform their best and does not adversely affect the performance of particular students (or groups of students). For ACT Aspire, the item and test design and development as well as scoring are designed to be sensitive to issues of fairness. Earlier chapters regarding test development, scoring, accessibility, scores, and reporting illustrate this commitment to fairness during the testing process.

# 13.3 Fairness in Test Accessibility

Fairness in accessibility refers to how easily test takers can show the knowledge or skills the test intends to measure without being unduly burdened by aspects of the test or administration that may limit access. For example, a student with a visual impairment may not be able to appropriately answer questions on a mathematics test if the student cannot see the test material. ACT Aspire includes a variety of accessibility options for students; additional details can be found in Chapter 5.

# 13.4 Fairness as Validity of Individual Test Score Interpretations for Intended Uses

The validity of score interpretations for the population served by an assessment is another consideration for fairness. It involves studying the validity of test score interpretations for different groups of students, but it also considers individuals, especially when scores are interpreted for individual students.

When evaluating validity in the context of fairness, it is particularly important to consider whether characteristics of the test may be underrepresented by or irrelevant to score interpretations for particular uses (see Chapter 12) and may affect different groups taking the test differently. These characteristics are often referred to as *construct under-representation* or *construct-irrelevant components* (e.g., AERA et al., 2014) and may lead to scores with different meanings, and therefore differential validity, across groups. Developing ACT Aspire tests requires processes and procedures that attempt to reduce characteristics of the tests that could adversely affect the validity of score interpretations across groups (e.g., see Chapter 2). Further, evaluating validity across groups requires evidence from analyses such as differential item functioning, differential test functioning, and predictive bias (e.g., AERA et al., pp. 51–52).

Evaluating fairness of an individual score is particularly important for tests like ACT Aspire, where score interpretations may be applied individually and uses may have implications for individual test takers. There are two aspects of validity at the individual level. One is whether the test can support interpretations of scores for intended uses for an individual student. For example, ACT Aspire scores are intended to provide instructionally actionable information, which could mean making inferences for individuals. ACT Aspire continually collects data to evaluate such evidence; relevant validity evidence can be found in Chapter 12.

A second aspect of validity is ensuring that a score interpretation for a particular student is valid for its intended use. For example, teachers and parents should consider scores and score interpretations from ACT Aspire in the context of what they know about their students and consider how valid they judge particular interpretations of scores for intended uses to be for each student. A teacher, parent, student, or other test user may know that scores do not reflect a student's achievement or that a student needs additional supports (e.g., test accommodations) for the scores to be appropriately interpreted. Best practices suggest using multiple sources of information when making decisions that affect individuals.

# 13.5 Differential Item Functioning Study for ACT Aspire

Measurement bias is "a source of invalidity that keeps some examinees with the trait or knowledge being measured from demonstrating that ability" (Shepard, Camilli, & Williams, 1985, p. 79). Measurement bias threatens the validity of test scores and interpretations. To investigate potential measurement bias for the ACT Aspire Summative Assessments, ACT evaluates the internal structure of the English, mathematics, reading, and science tests by investigating the invariance of the items and the overall assessment. For each new operational form of ACT Aspire, ACT follows rigorous item and form development procedures (see Chapter 2) and routinely conducts differential item functioning (DIF; Holland & Wainer, 1993) studies to ensure that operational forms are as fair as possible for all examinees.

## 13.5.1 Differential Item Functioning Methods and Procedures

DIF is a statistical indicator used to identify items to which individuals from one group respond differently than individuals from another group. DIF occurs when equally able examinees have different probabilities of answering a test item correctly based on their group membership (AERA, APA, & NCME, 2014). DIF is one indication of possible item bias although statistical evidence alone is not sufficient to conclude measurement bias. A large number of items showing DIF would be a possible indicator of test bias.
For ACT Aspire, the DIF study is conducted on operational response data with a focus on gender and ethnicity groups as shown in Table 13.1.

**Table 13.1. Differential Item Functioning Comparisons Groups**

| Group Membership | Focal Group | Reference Group |
|---|---|---|
| Gender | Female | Male |
| Ethnicity | African American | Caucasian |
| Ethnicity | Hispanic | Caucasian |

For ACT Aspire assessments, the Mantel-Haenszel procedure (MH; Holland & Thayer, 1988) is used for DIF analysis. The MH procedure has been widely used in DIF studies and is considered effective and efficient (Clauser & Mazor, 1998; Hills, 1989). For dichotomously scored items, MH examines both a statistical significance test and an analysis of the effect size; for polytomously scored items, ACT uses an extension of the MH procedure that requires computing the standardized mean difference (SMD) to indicate the magnitude of DIF sizes (e.g., Dorans & Schmitt, 1991; Zwick, 1993). For ACT Aspire, the former is applied to selected-response (SR) and technology-enhanced (TE) items and the latter to constructed-response (CR) items.

Specific rules developed by Educational Testing Service testing programs (e.g., Holland & Thayer, 1988; Zieky, 1993; Zwick, 2012; Zwick & Kadriye, 1989; Zwick, Thayer, & Mazzeo, 1997) are used to interpret the results of the DIF analyses. In addition to the MH chi-square statistic and its statistical significance level, the DIF analysis used to classify items as A (insignificant DIF), B (slight to moderate DIF), or C (moderate to large DIF) (see Table 13.2) includes the absolute value of the MH delta (MHD) difference for SR and TE items, and the SMD and its effect size (i.e., SMD divided by the total group standard deviation of the item scores) for CR items. The cutoff values for classifying items into different DIF categories for these statistics are also provided in Table 13.2.

**Table 13.2. ACT Aspire DIF Classification Rules**

| | Classification Rules | |
|---|---|---|
| DIF Classification | Selected-Response & Technology-Enhanced Items | Constructed-Response Items |
| A | {MH chi-square statistic not significantly different from 0 at the 5% significance level} or {\|MHD\| < 1.0} | {MH chi-square statistic not significantly different from 0 at the 5% significance level} or {\|SMD*/SD\| < 0.17} |
| B | {MH chi-square statistic significantly different from 0 at the 5% significant level} and {1.0 ≤ \|MHD\| < 1.5}; or {MH chi-square statistic not significantly different from 0 at the 5% significance level and \|MHD\| ≥ 1.0} | {MH chi-square statistic not significantly different from 0 at the 5% significance level} and {0.17 ≤ \|SMD/SD\| < 0.25} |
| C | {\|MHD\| > 1.0 at the 5% significance level} and {\|MHD\| ≥ 1.5} | {MH chi-square statistic significantly different from 0 at the 5% significance level} and {\|SMD/SD\| ≥ 0.25} |

* SMD denotes the standardized mean difference to indicate the magnitude of DIF sizes.

## 13.5.2 Differential Item Functioning Analysis Results

For English, mathematics, reading, and science, Table 13.3 contains the results of DIF analysis for gender for the ACT Aspire online and paper forms administered in the 2017–2018 academic year. Table 13.4 shows the results of DIF analysis for ethnicity for online forms only; those for paper forms were not reported due to inadequate sample sizes. In the table, the number of items (test length) for each grade's test is also presented. All DIF analyses were done by form (i.e., by subject, grade, and testing mode). For each item, comparisons were made based upon hundreds to thousands of examinees.

Across subjects, grades, and testing modes, the vast majority of the test items were classified as A items, showing little or no DIF. Items classified as B or C items were flagged. Note that flagging an item does not mean the item is necessarily biased; some items that are flagged as appear to favor one group over another might just be due to random fluctuations in samples. Items that are statistically flagged are further reviewed by content and measurement specialists.

**Table 13.3. Summary of Gender DIF Analysis Results for ACT Aspire Forms Administered in the 2017–2018 Academic Year: Percentages of A, B, and C Items by Subject, Grade, and Testing Mode**

| English | | Online | | | Paper | | |
|---|---|---|---|---|---|---|---|
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 31 | 99.2 | 0.8 | 0 | 100.0 | 0 | 0 |
| 4 | 31 | 100.0 | 0 | 0 | 99.2 | 0.8 | 0 |
| 5 | 31 | 98.4 | 1.6 | 0 | 98.4 | 1.6 | 0 |
| 6 | 35 | 95.7 | 3.6 | 0.7 | 95.7 | 2.9 | 1.4 |
| 7 | 35 | 97.9 | 2.1 | 0 | 97.9 | 1.4 | 0.7 |
| 8 | 35 | 97.9 | 2.1 | 0 | 94.3 | 5.7 | 0 |
| EHS | 50 | 96.5 | 3.0 | 0.5 | 95.5 | 3.0 | 1.5 |
| **Mathematics** | | **Online** | | | **Paper** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 30 | 91.7 | 6.7 | 1.7 | 94.2 | 2.5 | 3.3 |
| 4 | 30 | 86.7 | 11.7 | 1.7 | 90.0 | 8.3 | 1.7 |
| 5 | 30 | 90.8 | 7.5 | 1.7 | 91.7 | 7.5 | 0.8 |
| 6 | 36 | 88.2 | 7.6 | 4.2 | 91.7 | 4.9 | 3.5 |
| 7 | 36 | 87.5 | 9.0 | 3.5 | 88.2 | 8.3 | 3.5 |
| 8 | 42 | 93.5 | 4.8 | 1.8 | 93.5 | 6.0 | 0.6 |
| EHS | 42 | 91.1 | 7.7 | 1.2 | 91.1 | 7.1 | 1.8 |
| **Reading** | | **Online** | | | **Paper** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 24 | 95.8 | 3.1 | 1.0 | 97.9 | 2.1 | 0 |
| 4 | 24 | 97.9 | 2.1 | 0 | 96.9 | 3.1 | 0 |
| 5 | 24 | 93.8 | 5.2 | 1.0 | 96.9 | 3.1 | 0 |
| 6 | 24 | 90.6 | 6.3 | 3.1 | 94.8 | 5.2 | 0 |
| 7 | 24 | 92.7 | 6.3 | 1.0 | 96.9 | 3.1 | 0 |
| 8 | 24 | 91.7 | 5.2 | 3.1 | 93.8 | 5.2 | 1.0 |
| EHS | 24 | 94.8 | 3.1 | 2.1 | 87.5 | 10.4 | 2.1 |
| **Science** | | **Online** | | | **Paper** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 32 | 98.4 | 1.6 | 0 | 97.7 | 2.3 | 0 |
| 4 | 32 | 98.4 | 1.6 | 0 | 97.7 | 2.3 | 0 |
| 5 | 32 | 94.5 | 5.5 | 0 | 89.8 | 10.2 | 0 |
| 6 | 36 | 92.4 | 6.3 | 1.4 | 90.3 | 8.3 | 1.4 |
| 7 | 36 | 95.1 | 4.9 | 0 | 91.7 | 8.3 | 0 |
| 8 | 36 | 97.9 | 2.1 | 0 | 95.1 | 4.9 | 0 |
| EHS | 36 | 97.9 | 2.1 | 0 | 94.4 | 4.9 | 0.7 |

*Note*. For a subject, percentages within a grade and one testing mode may not add up to 100% due to rounding.

**Table 13.4. Summary of Ethnicity DIF Analysis Results for ACT Aspire Online Forms Administered in the 2017–2018 Academic Year: Percentages of A, B, and C Items by Subject and Grade**

| English | | Caucasians vs. African Americans | | | Caucasians vs. Hispanics | | |
|---|---|---|---|---|---|---|---|
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 31 | 92.7 | 5.6 | 1.6 | 91.1 | 5.6 | 3.2 |
| 4 | 31 | 93.5 | 5.6 | 0.8 | 93.5 | 5.6 | 0.8 |
| 5 | 31 | 95.2 | 4.8 | 0 | 95.2 | 3.2 | 1.6 |
| 6 | 35 | 92.9 | 5.7 | 1.4 | 97.1 | 1.4 | 1.4 |
| 7 | 35 | 97.1 | 2.9 | 0 | 96.4 | 3.6 | 0 |
| 8 | 35 | 91.4 | 7.1 | 1.4 | 96.4 | 3.6 | 0 |
| EHS | 50 | 96.0 | 3.5 | 0.5 | 97.0 | 2.5 | 0.5 |
| **Mathematics** | | **Caucasians vs. African Americans** | | | **Caucasians vs. Hispanics** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 30 | 90.8 | 8.3 | 0.8 | 100.0 | 0 | 0 |
| 4 | 30 | 93.3 | 5.8 | 0.8 | 97.5 | 2.5 | 0 |
| 5 | 30 | 94.2 | 5.0 | 0.8 | 99.2 | 0.8 | 0 |
| 6 | 36 | 93.8 | 4.2 | 2.1 | 97.9 | 1.4 | 0.7 |
| 7 | 36 | 88.9 | 9.7 | 1.4 | 99.3 | 0.7 | 0 |
| 8 | 42 | 94.0 | 4.2 | 1.8 | 98.8 | 1.2 | 0 |
| EHS | 42 | 95.2 | 4.2 | 0.6 | 100.0 | 0 | 0 |
| **Reading** | | **Caucasians vs. African Americans** | | | **Caucasians vs. Hispanics** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 24 | 97.9 | 1.0 | 1.0 | 97.9 | 1.0 | 1.0 |
| 4 | 24 | 97.9 | 2.1 | 0 | 96.9 | 3.1 | 0 |
| 5 | 24 | 97.9 | 2.1 | 0 | 94.8 | 5.2 | 0 |
| 6 | 24 | 95.8 | 3.1 | 1.0 | 95.8 | 3.1 | 1.0 |
| 7 | 24 | 95.8 | 3.1 | 1.0 | 96.9 | 3.1 | 0 |
| 8 | 24 | 94.8 | 3.1 | 2.1 | 93.8 | 6.3 | 0 |
| EHS | 24 | 93.8 | 5.2 | 1.0 | 94.8 | 5.2 | 0 |
| **Science** | | **Caucasians vs. African Americans** | | | **Caucasians vs. Hispanics** | | |
| Grade | Test Length | A | B | C | A | B | C |
| 3 | 32 | 97.7 | 1.6 | 0.8 | 99.2 | 0.8 | 0 |
| 4 | 32 | 96.1 | 3.1 | 0.8 | 99.2 | 0.8 | 0 |
| 5 | 32 | 97.7 | 0 | 2.3 | 100.0 | 0 | 0 |
| 6 | 36 | 95.8 | 4.2 | 0 | 98.6 | 1.4 | 0 |
| 7 | 36 | 95.1 | 4.9 | 0 | 97.2 | 2.8 | 0 |
| 8 | 36 | 97.2 | 2.1 | 0.7 | 98.6 | 1.4 | 0 |
| EHS | 36 | 97.9 | 2.1 | 0 | 99.3 | 0.7 | 0 |

*Note*. For a subject, percentages within a grade may not add up to 100% due to rounding.

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Chapter 14

# Growth Interpretations

ACT Aspire score reports include the following components, which all contribute to interpretations of growth:

- Longitudinal progress charts with a student's current and prior year's scores in English, mathematics, reading, and science
- Classification of a student's scores into ACT Readiness Levels (Chapter 9), showing how a student scored relative to the ACT Readiness Benchmarks
- Predicted paths, which predict a range of a student's Aspire test scores over the next two years
- Predicted 10th-grade PreACT score range and predicted 11th-grade ACT score range
- Classification of student growth as low, average, or high based on student growth percentiles (SGPs)

The latter three components (predicted Aspire score ranges, predicted PreACT and ACT score ranges, and SGPs) are described in this chapter. Other topics discussed in this chapter include gain scores, growth-to-standards models, measurement error of growth scores, and aggregate growth scores for research and evaluation.

## 14.1 Predictions

Score predictions can be used to:

- Determine if students are likely to meet ACT Readiness Benchmarks over the next two years
- Predict future achievement for a classroom, school, district, or state
- Predict 10th-grade PreACT score ranges (for grades 6 to 9)
- Predict 11th-grade ACT score ranges (for grades 6 to 10)

Predicted paths predict ACT Aspire score ranges over the next two years. Because the ACT Aspire assessment system ends in 10th grade, predicted paths for 9th-grade reports only cover one year, and 10th-grade reports do not include predicted paths. Predicted paths are a range, reflecting uncertainty in how a student will perform in the future. The paths are drawn by connecting the current year's score to the lower and upper values of the predicted score range. The predicted paths can be used to determine if students are likely to meet ACT Readiness Benchmarks over the next two years. The predicted paths assume typical growth, and the two-year predicted score ranges include the actual scores approximately 75 - 80% of the time. The one-year predicted ranges include the actual scores 50%–55% of the time. Predicted paths are reported for English, mathematics, reading, and science.

Predicted mean scores are used to form predicted paths for classrooms, schools, districts, states, and other user-defined groups. The aggregate predicted paths are drawn as lines connecting the current year's mean score to next year's predicted mean score. While the predicted paths for student score reports show a range of scores over two years, the predicted paths for groups only predict one year. Predicted mean scores for groups are calculated as the mean of students' predicted scores. Individual students' predicted scores are based on the estimated mean of the test score distribution, conditional on the previous year's test score.

Predicted 10th-grade PreACT score ranges are reported for students in grades 6–9, and predicted 11th-grade ACT score ranges are reported for students in grades 6–10. The PreACT and ACT score predictions assume typical growth and include the actual scores approximately 55% of the time. Predicted group mean PreACT and ACT scores are also reported and are calculated as the mean of students' predicted scores.

## 14.1.1 Samples Used to Derive the Predictions

Students who tested in multiple years form longitudinal samples used to derive the predicted paths. Each year, the longitudinal samples are updated with data from the most recent testing year. Here we describe the samples used in 2020 to derive the predicted paths that were used for reporting during the 2020–2021 academic year. ACT Aspire tests taken from fall 2015 through spring 2020 were used to derive the predicted paths.

For each pair of grades two years apart (e.g., 3–5, 4–6, 5–7, etc.) and for each subject, a stratified random sample of up to 25,000 students with scores from both grades was selected. The sampling procedure ensures that each longitudinal sample is similar to a common population (the 2019 ACT-tested graduating class) on race/ethnicity, school affiliation (public or nonpublic), and school percent eligible for free or reduced lunch (FRL). This also ensures that the samples are consistent across grades and subjects. The samples are not necessarily representative of the U.S. population because most students come from states that administered ACT Aspire over multiple years (Alabama, Arkansas, and Wisconsin). It is possible that predictions could shift with more school districts and states in the sample or with changes in student growth over time.

Table 14.1 summarizes the characteristics of the samples used to derive the predicted paths. (As discussed later in this chapter, a similar sampling design was used to generate the samples used to derive the student growth percentiles.) Note that the samples vary somewhat across grade level and subject area; Table 14.1 summarizes the total weighted sample.

**Table 14.1. Description of Samples Used for Predicted Paths and Student Growth Percentiles**

| | Sample % | |
|---|---|---|
| Sample Characteristic | Predicted Paths (2-year) | SGP (1-year) |
| Gender | | |
| Female | 49.7 | 49.6 |
| Male | 50.2 | 50.4 |
| Race/ethnicity | | |
| Black/African American | 12.6 | 12.8 |
| American Indian/Alaska Native | 1.0 | 1.1 |
| Asian | 4.5 | 4.8 |
| Hispanic | 15.7 | 16.7 |
| Native Hawaiian/OPI | 1.8 | 1.6 |
| Two or more races | 3.1 | 2.9 |
| White | 54.5 | 52.0 |
| Unknown race/ethnicity | 7.0 | 8.0 |
| English language learner | 7.2 | 7.0 |
| Economically disadvantaged | 45.8 | 46.7 |
| Special education | 8.3 | 8.1 |
| School type | | |
| Public, total | 87.7 | 88.1 |
| Public, 0%–25% FRL | 23.7 | 22.9 |
| Public, 25%–50% FRL | 31.7 | 29.6 |
| Public, 50%–75% FRL | 19.2 | 18.5 |
| Public, 75%–100% FRL | 4.9 | 7.6 |
| Public, FRL unknown | 8.2 | 9.6 |
| Nonpublic | 10.3 | 9.9 |
| Unknown school type | 2.0 | 2.0 |

*Note*. OPI = other Pacific Islander.

Students who took the PreACT test in spring of 10th grade after having taken ACT Aspire in the spring of grades 6, 7, 8, or 9 were used to derive the predicted PreACT score ranges. Similarly, students who took the ACT test in spring of 11th grade after having taken ACT Aspire in the spring of grades 6, 7, 8, 9, or 10 were used to derive the predicted ACT score ranges. Each year, the longitudinal samples are updated with data from the most recent testing year. Using data collected through spring 2020, the PreACT and ACT predictions were updated for reporting during the 2020-2021 academic year.

Each sample -- defined by ACT Aspire grade level, subject area, and outcome (PreACT or ACT score) -- was weighted to match a common population (the 2019 ACT-tested graduating class) on race/ethnicity, school affiliation (public or nonpublic), and school percent eligible for free or reduced lunch (FRL). This ensures that the weighted samples are similar across grade levels and subject areas. Table 14.2 provides summary statistics for the ACT Aspire and PreACT scores used to derive the PreACT predictions using data collected through spring 2020. Similarly, Table 14.3 provides summary statistics for the ACT Aspire and ACT scores used to derive the ACT predictions using data collected through spring 2020.

Table 14.2. Summary Statistics for PreACT Score Predictions

| Subject | Grade | N | ACT Aspire Score | | PreACT Score | | r |
|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | |
| Composite | 6 | 12,636 | 422.9 | 6.1 | 18.9 | 5.3 | 0.84 |
| | 7 | 23,568 | 423.8 | 6.7 | 18.9 | 5.3 | 0.86 |
| | 8 | 27,702 | 425.7 | 7.1 | 18.7 | 5.1 | 0.87 |
| | 9 | 22,101 | 427.7 | 7.7 | 19.8 | 5.1 | 0.88 |
| English | 6 | 16,732 | 425.3 | 7.9 | 17.5 | 6.4 | 0.74 |
| | 7 | 24,205 | 427.9 | 8.6 | 17.6 | 6.5 | 0.74 |
| | 8 | 28,890 | 428.9 | 8.8 | 17.5 | 6.3 | 0.78 |
| | 9 | 23,484 | 431.0 | 9.8 | 18.3 | 6.1 | 0.79 |
| Mathematics | 6 | 46,479 | 420.9 | 6.2 | 18.1 | 4.7 | 0.71 |
| | 7 | 51,608 | 421.2 | 7.2 | 18.2 | 4.6 | 0.76 |
| | 8 | 52,506 | 424.0 | 8.1 | 18.1 | 4.6 | 0.79 |
| | 9 | 24,413 | 427.2 | 8.7 | 19.4 | 4.9 | 0.80 |
| Reading | 6 | 46,481 | 420.9 | 6.4 | 19.7 | 6.6 | 0.66 |
| | 7 | 51,572 | 421.2 | 6.2 | 19.8 | 6.5 | 0.69 |
| | 8 | 52,405 | 423.9 | 6.7 | 19.7 | 6.5 | 0.69 |
| | 9 | 23,850 | 424.3 | 7.7 | 21.0 | 6.6 | 0.71 |
| Science | 6 | 13,990 | 422.7 | 6.8 | 18.6 | 5.3 | 0.67 |
| | 7 | 50,952 | 423.0 | 7.5 | 18.5 | 5.1 | 0.70 |
| | 8 | 32,369 | 425.2 | 7.9 | 18.5 | 5.1 | 0.72 |
| | 9 | 23,265 | 427.5 | 8.8 | 19.8 | 5.4 | 0.73 |

**Table 14.3. Summary Statistics for ACT Score Predictions**

| Subject | Grade | N | ACT Aspire Score Mean | ACT Aspire Score SD | ACT Score Mean | ACT Score SD | r |
|---|---|---|---|---|---|---|---|
| Composite | 6 | 24,052 | 422.8 | 6.1 | 19.8 | 5.7 | 0.83 |
| | 7 | 67,555 | 424.0 | 6.6 | 19.9 | 5.6 | 0.84 |
| | 8 | 128,205 | 425.9 | 7.1 | 19.8 | 5.5 | 0.85 |
| | 9 | 358,345 | 425.9 | 7.8 | 19.6 | 5.4 | 0.88 |
| | 10 | 541,819 | 427.5 | 8.3 | 19.6 | 5.3 | 0.88 |
| English | 6 | 29,787 | 425.5 | 8.0 | 19.5 | 7.0 | 0.72 |
| | 7 | 75,554 | 428.2 | 8.4 | 19.7 | 7.0 | 0.73 |
| | 8 | 136,510 | 429.0 | 8.8 | 19.5 | 6.9 | 0.77 |
| | 9 | 364,210 | 428.8 | 10.0 | 18.8 | 6.5 | 0.81 |
| | 10 | 550,016 | 431.0 | 10.4 | 18.9 | 6.5 | 0.82 |
| Mathematics | 6 | 82,761 | 421.2 | 6.2 | 18.8 | 5.0 | 0.72 |
| | 7 | 155,180 | 421.4 | 7.2 | 18.9 | 5.0 | 0.77 |
| | 8 | 244,281 | 424.1 | 8.1 | 19.0 | 5.0 | 0.80 |
| | 9 | 366,597 | 425.7 | 8.5 | 19.3 | 5.1 | 0.81 |
| | 10 | 552,544 | 427.0 | 9.1 | 19.3 | 5.0 | 0.82 |
| Reading | 6 | 82,722 | 420.8 | 6.4 | 19.9 | 6.6 | 0.68 |
| | 7 | 154,959 | 421.2 | 6.2 | 19.9 | 6.5 | 0.69 |
| | 8 | 243,814 | 423.8 | 6.8 | 20.0 | 6.5 | 0.68 |
| | 9 | 366,107 | 422.8 | 7.7 | 19.8 | 6.4 | 0.72 |
| | 10 | 552,186 | 423.9 | 7.9 | 19.8 | 6.3 | 0.71 |
| Science | 6 | 30,839 | 422.5 | 6.8 | 19.7 | 5.5 | 0.70 |
| | 7 | 119,202 | 423.3 | 7.5 | 19.6 | 5.5 | 0.72 |
| | 8 | 144,806 | 425.4 | 7.8 | 19.7 | 5.5 | 0.73 |
| | 9 | 363,163 | 425.9 | 8.7 | 19.8 | 5.4 | 0.74 |
| | 10 | 548,929 | 427.4 | 9.2 | 19.8 | 5.3 | 0.75 |

## 14.1.2 Statistical Models Used to Derive the Predictions

The two-year predicted paths are based on a regression model where grade *g* test score is used to predict grade *g* + 2 test score. The regression model uses linear and quadratic effects of the grade *g* score to predict the grade *g* + 2 score, and a 70% prediction interval forms the endpoints of the two-year predicted score range. While all previous test scores are plotted on the student report, only the current year's test score is used to make predictions. Note that the 70% prediction interval typically results in a coverage rate of about 75-80% because the test scores are integers and scores that equal the interval endpoints are considered in the interval. The predicted path is drawn by connecting the current year's score to the endpoints of the two-year predicted path. This is the approach used for English, mathematics, reading, and science for grades 3–8.

For grade 9, only one-year predicted paths are reported because the ACT Aspire assessment system ends in grade 10. The predicted path endpoints are defined as the scores closest to the 25th and 75th percentiles of the grade 10 score distribution, conditional on grade 9 score. The quantiles of the conditional score distribution are estimated using the same methods used to estimate student growth percentiles (described later in this chapter). The predicted PreACT and ACT scores are  based on regression models where the outcome (PreACT or ACT score) is regressed on the linear and quadratic effects of prior ACT Aspire score.  A 50% prediction interval forms the endpoints of the predicted score ranges, resulting a typical coverage rate of approximately 55%.

# 14.2 Student Growth Percentiles

Student growth percentiles (SGPs) represent the rank of a student's test score compared to the scores of students with the same prior year scores. ACT Aspire SGPs, ranging from 1 to 100, are provided for students who test in consecutive years approximately one year apart. Growth is classified as *low* (SGP < 25), *average* (25 ≤ SGP ≤ 75), or *high* (SGP > 75).

SGPs are estimated using quantile regression methods (Koenker, 2005) by the SGP R package (Betebenner, VanIwaarden, Domingue, & Shang, 2014). When interpreting SGPs, the reference group used to estimate the model should always be considered. Characteristics of the sample used to estimate the SGPs reported during the 2020–2021 academic year are given in Table 14.1. The SGP samples consist of students who tested in consecutive years approximately one year apart (e.g., grade 3-4, 4-5, ..., 9-10).  The sampling design used for the two-year predicted paths was also used for the SGP samples, resulting in greater consistency across grade levels and subject areas.

The SGPs are updated annually, so they can shift over time. For additional information on SGPs, see *ACT Growth Modeling Resources* online. The online resources include different versions of the ACT Aspire SGP tables as well as SGP tables for ACT Aspire-to-PreACT and ACT Aspire-to-ACT. The online resources also include SGPs corresponding to ELA, STEM, and Composite scores.

## 14.2.1 Consistency of SGPs Across Subjects

Using all longitudinal data collected through spring 2018, we examined the correlations of SGPs across subjects. A positive correlation indicates consistency between SGPs for different subjects, and a negative correlation indicates inconsistency between SGPs for different subjects. In Table 14.4, the correlations are presented for each pair of subjects. The sample used to estimate each correlation includes each instance of different subject tests being taken in consecutive years. Results are presented for all grades combined.

All the correlations in Table 14.4 are positive and range from 0.18 (English and mathematics) to 0.25 (reading and science). The correlations provide some evidence of consistency between SGPs for different subjects. Students who demonstrate high (or low) growth in one subject are more likely to also demonstrate high (or low) growth in other subjects. Possible explanations for this consistency in SGPs across subjects include (a) developing knowledge and skills in one subject may influence development in other subjects, and (b) growth across subjects may be driven by a shared factor, such as motivation. The correlations are relatively small, suggesting modest levels of consistency. The correlations are attenuated toward 0 because of measurement error in the SGPs.

**Table 14.4. Correlations of SGPs Across Subjects**

| Subject | English | Mathematics | Reading | Science |
|---|---|---|---|---|
| English | 1.00 | | | |
| Mathematics | 0.18 | 1.00 | | |
| Reading | 0.22 | 0.19 | 1.00 | |
| Science | 0.21 | 0.22 | 0.25 | 1.00 |

*Note*. The correlations are based on sample sizes of 1.3 to 1.9 million.

## 14.2.2 Correlations of ACT Aspire Interim Scores and SGPs

The ACT Aspire Interim assessments can be administered at any time during the academic year to provide information about students' progress toward end-of-year learning goals (ACT, 2018). The interim tests are shorter versions of the ACT Aspire Summative tests and cover the same subjects (English, math, reading, and science) and grades (3–10) as ACT Aspire Summative. The interim tests are selected-response tests and offer immediate score reporting.

When students take an ACT Aspire Interim assessment, a predicted end-of-year ACT Aspire Summative score is produced. When multiple interim tests are taken during an academic year, the prediction uses the last three test scores using multiple linear regression (ACT, 2018, p. 12.2). Typically, multiple interim tests are given during the academic year, before the spring Summative Assessment. The SGPs measure growth from one year's spring Summative Assessment to the next year's spring Summative Assessment.

If interim performance and SGPs are both indicators of a student's progress over the course of an academic year, we'd expect the two measures to be positively correlated.

As part of another study (Allen, 2019), the correlations of ACT Aspire Interim scores and SGPs (based on ACT Aspire Summative tests) were examined. Predicted end-of-year summative scores were used as a summary measure of performance on the interim tests. Table 14.5 reports the sample sizes and correlations for each subject and grade. The correlations describe the strength of the relationship between interim performance and the previous year's summative score, the current year's summative score, and SGP. Across subjects and grades, the average correlation of interim performance with the current year's summative score was 0.79, slightly higher than the average correlation of interim performance with the previous year's summative score (0.76). Because the interim tests are shorter versions of the summative tests, the scores are expected to be highly correlated.

Correlations of interim performance with SGP ranged from 0.22 (math, grades 8–9) to 0.39 (English, grades 5–6), with an average correlation of 0.31. The positive correlations of interim performance and SGP suggest that students who perform better on the ACT Aspire Interim assessments are more likely to demonstrate higher growth on the ACT Aspire Summative Assessments. The evidence supports using interim test scores and SGPs to indicate a student's progress over an academic year.

**Table 14.5. Correlations of Aspire Interim Scores with Aspire Summative Scores and Growth**

| | | | Correlations with Interim Performance | | |
|---|---|---|---|---|---|
| Subject | Grade Pair | N | Prior year Summative score | Current year Summative score | Summative SGP |
| English | 3–4 | 3,146 | 0.75 | 0.79 | 0.37 |
| | 4–5 | 2,664 | 0.78 | 0.80 | 0.36 |
| | 5–6 | 3,593 | 0.75 | 0.81 | 0.39 |
| | 6–7 | 3,526 | 0.75 | 0.80 | 0.35 |
| | 7–8 | 3,828 | 0.76 | 0.79 | 0.37 |
| | 8–9 | 3,653 | 0.82 | 0.85 | 0.32 |
| | 9–10 | 6,675 | 0.83 | 0.85 | 0.28 |
| Math | 3–4 | 14,243 | 0.70 | 0.77 | 0.32 |
| | 4–5 | 13,939 | 0.71 | 0.77 | 0.33 |
| | 5–6 | 13,384 | 0.69 | 0.71 | 0.26 |
| | 6–7 | 13,574 | 0.74 | 0.78 | 0.31 |
| | 7–8 | 14,422 | 0.76 | 0.81 | 0.29 |
| | 8–9 | 3,348 | 0.80 | 0.80 | 0.22 |
| | 9–10 | 7,061 | 0.80 | 0.81 | 0.24 |
| Reading | 3–4 | 14,867 | 0.75 | 0.78 | 0.33 |
| | 4–5 | 14,716 | 0.76 | 0.77 | 0.29 |
| | 5–6 | 14,241 | 0.73 | 0.76 | 0.30 |
| | 6–7 | 14,314 | 0.74 | 0.76 | 0.30 |
| | 7–8 | 14,694 | 0.72 | 0.75 | 0.32 |
| | 8–9 | 4,734 | 0.74 | 0.77 | 0.35 |
| | 9–10 | 8,758 | 0.74 | 0.76 | 0.29 |
| Science | 3–4 | 5,228 | 0.78 | 0.80 | 0.32 |
| | 4–5 | 5,269 | 0.77 | 0.80 | 0.32 |
| | 5–6 | 4,983 | 0.76 | 0.80 | 0.32 |
| | 6–7 | 4,740 | 0.76 | 0.80 | 0.31 |
| | 7–8 | 6,350 | 0.76 | 0.78 | 0.29 |
| | 8–9 | 3,963 | 0.81 | 0.81 | 0.27 |
| | 9–10 | 6,499 | 0.80 | 0.81 | 0.28 |

## 14.2.3 SGP Differences Across Student and School Subgroups

Analyses were conducted to examine SGP differences across student and school subgroups. The subgroups are defined by gender, race/ethnicity, English language learner status, economic disadvantage status, special education status (participation in an individualized education program), school affiliation (public or nonpublic), and school percent eligible for free or reduced lunch (FRL). The student subgroup indicators are provided by school or district personnel, and the school variables are obtained from the National Center for Education Statistics Common Core of Data (Glander, 2016). The 2018 version of the SGPs (used for reporting in the 2018–2019 academic year) was used for this analysis.

In Table 14.6, the SGP sample sizes for each subgroup are presented, using all longitudinal data collected through spring 2018. In Table 14.7, the mean SGP for each subgroup is presented, with results aggregated across grades. Because the SGP is a percentile rank, the mean SGP among all students should be close to 50. Recall that stratified random sampling was used to derive the SGP samples, whereas Table 14.7 is based on all longitudinal data collected through spring 2018. In Table 14.7, we see that the mean SGP for all students ranges from 48.4 in mathematics to 48.9 in English and science. Thus, we can conclude that the mean SGP is slightly lower for the general ACT Aspire user population than it is for the stratified random samples.

Across all subjects, female students had higher mean SGP than male students. The difference was largest for English (50.7 for females, 47.1 for males) and smallest for science (49.6 for females, 48.2 for males). By race/ethnicity, mean SGPs were consistently higher for Asian students and lowest for African American students. The mean SGPs for white students were slightly above the total group average, ranging from 50.6 in reading to 50.9 in science. For Hispanic students, mean SGPs ranged from 46.5 in English to 47.2 in mathematics.

Mean SGPs for English language learners were below the total group average, ranging from 42.4 in English to 44.6 in science. Similarly, for economically disadvantaged students, mean SGP ranged from 45.5 in English to 46.5 in reading. Across student subgroups, mean SGPs were lowest for special education students, ranging from 37.4 in English to 39.3 in science.

Mean SGPs were lower for students from public schools than for students from nonpublic schools, with the largest difference in English (47.9 for public, 53.4 for nonpublic). Within public schools, mean SGPs were lower for schools with higher percent eligible for free or reduced lunch.

**Table 14.6. SGP Sample Sizes, by Subgroup**

| Subgroup | Subject | | | |
|---|---|---|---|---|
| | English | Mathematics | Reading | Science |
| Total | 1,367,165 | 1,956,184 | 1,949,375 | 1,404,456 |
| Gender | | | | |
| Female | 672,618 | 961,536 | 958,431 | 691,227 |
| Male | 692,713 | 992,595 | 988,905 | 711,201 |
| Race/ethnicity | | | | |
| Black/African American | 216,580 | 396,542 | 396,533 | 236,383 |
| American Indian/Alaska Native | 9,746 | 14,284 | 14,207 | 10,101 |
| Asian | 35,343 | 43,218 | 42,779 | 34,031 |
| Hispanic | 139,181 | 181,532 | 179,033 | 145,300 |
| Native Hawaiian/OPI | 15,429 | 15,181 | 14,959 | 12,450 |
| Two or more races | 21,883 | 22,573 | 22,529 | 21,640 |
| White | 696,333 | 1,040,479 | 1,038,974 | 750,325 |
| English language learner | 59,175 | 64,675 | 62,457 | 56,456 |
| Economically disadvantaged | 486,609 | 736,794 | 734,824 | 549,832 |
| Special education | 99,418 | 136,253 | 136,050 | 107,367 |
| School type | | | | |
| Public, total | 1,085,598 | 1,666,915 | 1,661,832 | 1,132,781 |
| Public, 0%–25% FRL | 147,886 | 214,571 | 213,630 | 151,313 |
| Public, 25%–50% FRL | 347,025 | 508,859 | 507,670 | 371,831 |
| Public, 50%–75% FRL | 389,043 | 671,160 | 669,052 | 417,262 |
| Public, 75%–100% FRL | 182,630 | 245,580 | 245,005 | 174,748 |
| Nonpublic | 222,679 | 224,362 | 223,506 | 216,691 |

*Note*. OPI = other Pacific Islander.

**Table 14.7. Mean SGP, by Subgroup**

| | Subject | | | |
|---|---|---|---|---|
| Subgroup | English | Mathematics | Reading | Science |
| Total | 48.9 | 48.4 | 48.8 | 48.9 |
| Gender | | | | |
| Female | 50.7 | 49.1 | 50.5 | 49.6 |
| Male | 47.1 | 47.7 | 47.1 | 48.2 |
| Race/ethnicity | | | | |
| Black/African American | 42.6 | 41.8 | 43.5 | 42.5 |
| American Indian/Alaska Native | 46.9 | 48.0 | 48.0 | 47.9 |
| Asian | 52.4 | 54.2 | 54.0 | 53.5 |
| Hispanic | 46.5 | 47.2 | 47.1 | 47.0 |
| Native Hawaiian/OPI | 42.8 | 40.6 | 43.0 | 41.4 |
| Two or more races | 49.2 | 49.6 | 50.0 | 49.0 |
| White | 50.7 | 50.8 | 50.6 | 50.9 |
| English language learner | 42.4 | 44.3 | 43.6 | 44.6 |
| Economically disadvantaged | 45.5 | 46.1 | 46.5 | 46.1 |
| Special education | 37.4 | 37.9 | 38.1 | 39.3 |
| School type | | | | |
| Public, total | 47.9 | 47.9 | 48.2 | 48.3 |
| Public, 0%–25% FRL | 52.1 | 53.9 | 53.2 | 52.4 |
| Public, 25%–50% FRL | 49.5 | 50.0 | 49.6 | 50.0 |
| Public, 50%–75% FRL | 46.8 | 46.3 | 46.9 | 47.1 |
| Public, 75%–100% FRL | 43.7 | 43.0 | 44.5 | 44.0 |
| Nonpublic | 53.4 | 51.8 | 52.6 | 52.1 |

*Note*. OPI = other Pacific Islander.

# 14.3 Gain Scores

ACT Aspire English, mathematics, reading, and science scores are vertically scaled across grades (Chapter 10), making it possible to monitor progress over time on the same scale. Viewing scores graphically over multiple years provides insights about a student's current achievement level as well as progress made with respect to the ACT Readiness Levels. Gain scores are the arithmetic difference in scores from one year to the next. Positive mean gain scores are anticipated because students are expected to increase their knowledge and skills each year.

Gain scores are an attractive growth measure because they are simple and intuitive. While SGPs describe growth relative to other students (i.e., norm-referenced), gain scores describe growth in absolute terms. However, the average gain can vary considerably across subjects and grades, so normative information is still helpful to interpret gain scores. For example, the mean gain score can be used to determine if a student's gain is higher or lower than average.

For the same longitudinal samples used to derive the SGPs in 2020 (see Table 14.1), gain score statistics are provided in Table 14.8. In addition to mean scores (prior year, current year, and gain), Table 14.8 shows the standard deviation of the gain scores, the mean gain score expressed as an effect size, and the correlation (r) of prior year and current year test scores.

**Table 14.8. ACT Aspire Gain Score Statistics**

| | | Mean Score | | Gain Score | | | |
|---|---|---|---|---|---|---|---|
| Subject | Grade Pair | Prior | Current | Mean | SD | Effect Size | r |
| English | 3-4 | 417.46 | 420.62 | 3.16 | 4.50 | 0.50 | 0.76 |
| | 4-5 | 420.38 | 423.44 | 3.06 | 4.64 | 0.46 | 0.77 |
| | 5-6 | 423.30 | 425.75 | 2.46 | 5.34 | 0.35 | 0.78 |
| | 6-7 | 425.56 | 428.00 | 2.44 | 5.70 | 0.29 | 0.78 |
| | 7-8 | 427.76 | 428.54 | 0.78 | 5.76 | 0.09 | 0.80 |
| | 8-9 | 427.84 | 428.75 | 0.91 | 6.07 | 0.10 | 0.82 |
| | 9-10 | 427.68 | 429.77 | 2.10 | 6.18 | 0.21 | 0.83 |
| Mathematics | 3-4 | 413.55 | 416.44 | 2.90 | 3.01 | 0.66 | 0.77 |
| | 4-5 | 416.40 | 418.20 | 1.80 | 3.61 | 0.41 | 0.76 |
| | 5-6 | 418.14 | 421.25 | 3.11 | 4.19 | 0.57 | 0.76 |
| | 6-7 | 421.36 | 421.76 | 0.39 | 4.84 | 0.06 | 0.78 |
| | 7-8 | 421.59 | 424.51 | 2.91 | 4.90 | 0.38 | 0.82 |
| | 8-9 | 423.61 | 424.85 | 1.23 | 5.04 | 0.15 | 0.82 |
| | 9-10 | 424.61 | 426.26 | 1.64 | 5.30 | 0.19 | 0.83 |
| Reading | 3-4 | 413.14 | 415.78 | 2.65 | 4.01 | 0.47 | 0.77 |
| | 4-5 | 415.69 | 417.80 | 2.10 | 4.33 | 0.34 | 0.76 |
| | 5-6 | 417.56 | 419.66 | 2.09 | 4.69 | 0.33 | 0.75 |
| | 6-7 | 419.58 | 420.50 | 0.92 | 4.70 | 0.13 | 0.76 |
| | 7-8 | 420.58 | 423.24 | 2.66 | 4.99 | 0.40 | 0.75 |
| | 8-9 | 422.64 | 422.39 | -0.25 | 5.47 | -0.03 | 0.75 |
| | 9-10 | 421.93 | 422.80 | 0.87 | 5.72 | 0.11 | 0.75 |
| Science | 3-4 | 415.53 | 418.28 | 2.75 | 4.44 | 0.41 | 0.78 |
| | 4-5 | 418.11 | 420.33 | 2.22 | 4.49 | 0.33 | 0.77 |
| | 5-6 | 420.12 | 421.80 | 1.67 | 4.44 | 0.25 | 0.80 |
| | 6-7 | 422.00 | 423.04 | 1.04 | 4.76 | 0.14 | 0.81 |
| | 7-8 | 422.92 | 424.88 | 1.96 | 5.02 | 0.25 | 0.81 |
| | 8-9 | 424.10 | 425.48 | 1.38 | 5.53 | 0.17 | 0.79 |
| | 9-10 | 424.70 | 426.19 | 1.50 | 5.94 | 0.17 | 0.80 |

*Note*. SD = standard deviation; effect size = mean gain divided by the standard deviation of the prior year's score.

There is considerable variation across grades and subjects in mean gain scores. As expected, most of the mean gain scores are positive, showing that students in the sample typically increased their knowledge and skills after one year of schooling. The one exception is for reading grade 8–9 (mean gain = −0.25); the mean gain is also very small for mathematics grades 6–7 (0.39). Generally, mean gain scores are higher for lower grades, which is consistent with data from other assessment programs (Scammacca, Fall, & Roberts, 2015). The mean gain scores suggest that typical gain from grade 3 to grade 10 is 14.9 points for English, 14.0 points for mathematics, 11.0 points for reading, and 12.5 points for science.

## 14.3.1 Interpreting Gain Scores

Because ACT Aspire scores are reported on a vertical scale, gain scores are intended to measure change in knowledge and skills from one year's test to another. However, because no educational scale can be interpreted as having strictly equal intervals, it should not be assumed that the meaning of gain scores is the same across the score scale. Some regions of the score scale may be more sensitive to student learning. And students who score at the low end of a scale are generally expected to have larger one-year gain scores than students who score at the high end. This phenomenon is illustrated in Figure 14.1 using a sample of students who took the English test in grades 7 and 8. The figure shows the mean gain score, as well as the 25th and 75th percentile of the gain score distribution, for each grade 7 English score point with a sample size of at least 100 students. The negative relationship between the prior year's score and gain score exists because test scores are only estimates of true achievement levels: Students who score far above (or below) the mean are more likely than others to have scored above (or below) their true achievement level and tend to score closer to the mean the next year. This phenomenon is a form of regression to the mean that is caused by measurement error in test scores.

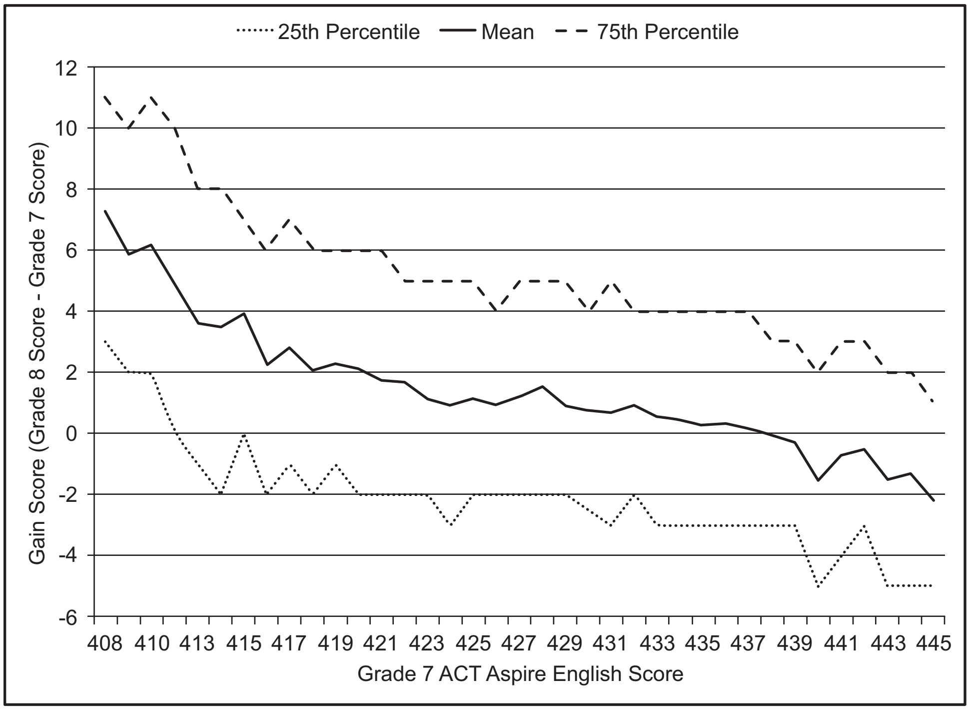


**Figure 14.1. Gain score statistics for grades 7–8 English.**

Figure 14.1 also demonstrates that there is significant variation in gain scores. The standard deviations of gain scores are also provided in Table 14.8. For English grades 7 and 8, the mean gain score is 0.78 and the standard deviation of the gain score is 5.76. Thus, most students have gain scores between −5 and 7 (mean gain +/− standard deviation of gain). Because the standard deviation is large relative to the mean, it is not uncommon for students to have negative gain scores. As discussed later in this chapter, both gain scores and SGPs are imprecise measures of growth and have a relatively large standard error of measurement (SEM). The large SEM is a primary cause of the large variation in gain scores.

# 14.4 Growth-to-Standards Models

Growth-to-standards models determine if students are making sufficient progress toward a performance standard, such as the ACT Readiness Benchmarks. ACT Aspire supports growth-to-standards models because scores over time are plotted against the ACT Readiness Benchmarks and ACT Readiness Levels. The predictions also support growth-to-standards models because they indicate how students are likely to perform in future years, assuming typical growth. For example, if a fourth grader's predicted path falls below the ACT Readiness Benchmark for grades 5 and 6, he or she knows that atypically high growth over the next two years will be needed to reach the ACT Readiness Benchmark.

Growth-to-standards models can be implemented by specifying a performance standard such as the ACT Readiness Benchmark and specifying the amount of time students have to reach the performance standard. For example, suppose a 6th-grade student's mathematics score is 414, which is 6 points below the Readiness Benchmark (420). If the goal is to catch up within two years, the student would need to gain 11 score points to reach the grade 8 ACT Readiness Benchmark for mathematics (425). Under a growth-to-standards model, the student would need to gain at least 5 points from grade 6 to grade 7 to have made sufficient progress toward the grade 8 performance standard. SGPs can also be used in a growth-to-standards model to communicate how much progress is needed using the growth percentile metric instead of the gain score metric. For example, an SGP of 84 would be needed to move from a 6th-grade mathematics score of 414 to a 7th-grade mathematics score of 419.

## 14.4.1 Transitioning Across ACT Aspire Readiness Levels

ACT Aspire's Readiness Levels include four levels: In Need of Support, Close, Ready, and Exceeding (Chapter 9). To better understand the percentage of students transitioning across readiness levels, we provide the relative frequency of each readiness level, conditional on the prior year's readiness level (Table 14.9). The percentages in Table 14.9 are based on the same samples used to derive the SGPs in 2020 (Table 14.1). As an example of how to interpret the percentages in Table 14.9, consider students in grade 4 who were at the Ready level in mathematics (see cells of Table 14.9 in the red box). Most of the students (57.9%) remained at the Ready level in grade 5, 10.3% improved to the Exceeding level, 30.1% dropped to the Close level, and 1.8% dropped to the In Need of Support level.

Table 14.9. Readiness Level Transition Percentages

| Subject | Grade Pair | Prior Year = In Need of Support (INS) | | | | Prior Year = Close (CL) | | | | Prior Year = Ready (RD) | | | | Prior Year = Exceeding (EX) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | INS | CL | RD | EX | INS | CL | RD | EX | INS | CL | RD | EX | INS | CL | RD | EX |
| English | 3-4 | 37.0 | 50.7 | 11.1 | 1.2 | 19.6 | 46.7 | 28.8 | 4.9 | 4.2 | 27.1 | 47.1 | 21.6 | 0.3 | 4.7 | 25.1 | 69.9 |
| | 4-5 | 25.3 | 57.0 | 17.2 | 0.5 | 8.8 | 49.3 | 37.8 | 4.1 | 1.1 | 18.8 | 54.1 | 26.0 | 0.1 | 2.2 | 22.5 | 75.3 |
| | 5-6 | 38.6 | 49.5 | 11.2 | 0.8 | 13.4 | 46.8 | 32.9 | 6.9 | 1.8 | 18.3 | 43.9 | 36.0 | 0.1 | 1.8 | 14.2 | 83.9 |
| | 6-7 | 28.3 | 51.7 | 18.7 | 1.3 | 11.5 | 40.3 | 40.1 | 8.0 | 2.0 | 15.4 | 47.7 | 34.9 | 0.2 | 1.8 | 15.0 | 83.1 |
| | 7-8 | 52.0 | 34.6 | 11.9 | 1.4 | 25.6 | 39.2 | 29.6 | 5.7 | 5.3 | 19.2 | 43.9 | 31.7 | 0.3 | 2.0 | 12.7 | 84.9 |
| | 8-9 | 75.4 | 20.9 | 3.2 | 0.4 | 45.5 | 38.5 | 14.5 | 1.6 | 15.0 | 33.3 | 38.1 | 13.7 | 1.4 | 6.6 | 22.6 | 69.5 |
| | 9-10 | 66.7 | 25.5 | 7.0 | 0.8 | 29.3 | 39.5 | 26.5 | 4.7 | 6.9 | 20.3 | 45.7 | 27.1 | 0.8 | 2.2 | 14.7 | 82.2 |
| Mathematics | 3-4 | 36.2 | 56.6 | 7.1 | 0.2 | 12.1 | 63.6 | 23.5 | 0.8 | 1.6 | 28.4 | 59.9 | 10.0 | 0.1 | 3.3 | 40.1 | 56.5 |
| | 4-5 | 39.9 | 54.8 | 5.1 | 0.2 | 15.0 | 64.0 | 20.1 | 0.9 | 1.8 | 30.1 | 57.9 | 10.3 | 0.1 | 2.7 | 36.7 | 60.5 |
| | 5-6 | 39.6 | 49.2 | 10.4 | 0.8 | 14.5 | 49.9 | 31.1 | 4.5 | 1.7 | 17.1 | 51.7 | 29.5 | 0.1 | 1.5 | 17.7 | 80.8 |
| | 6-7 | 74.5 | 22.3 | 3.1 | 0.1 | 39.4 | 44.0 | 15.0 | 1.5 | 9.5 | 34.4 | 39.8 | 16.3 | 0.6 | 5.9 | 24.7 | 68.8 |
| | 7-8 | 72.2 | 23.5 | 3.7 | 0.6 | 33.1 | 43.0 | 20.0 | 3.8 | 6.9 | 26.5 | 41.3 | 25.3 | 0.2 | 3.2 | 16.7 | 79.9 |
| | 8-9 | 83.8 | 13.9 | 2.2 | 0.2 | 45.3 | 37.4 | 15.2 | 2.1 | 13.4 | 34.3 | 37.1 | 15.2 | 1.4 | 7.3 | 27.4 | 63.9 |
| | 9-10 | 87.6 | 10.5 | 1.8 | 0.2 | 43.8 | 37.8 | 16.1 | 2.3 | 11.4 | 34.2 | 37.7 | 16.7 | 1.7 | 6.9 | 27.4 | 63.9 |

**Table 14.9. Readiness Level Transition Percentages—continued**

| Subject | Grade Pair | Prior Year = In Need of Support (INS) | | | | Prior Year = Close (CL) | | | | Prior Year = Ready (RD) | | | | Prior Year = Exceeding (EX) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | INS | CL | RD | EX | INS | CL | RD | EX | INS | CL | RD | EX | INS | CL | RD | EX |
| Reading | 3-4 | 60.3 | 30.2 | 8.8 | 0.7 | 16.6 | 43.3 | 32.8 | 7.3 | 3.4 | 24.0 | 46.0 | 26.6 | 0.6 | 5.7 | 32.0 | 61.6 |
| | 4-5 | 77.1 | 18.9 | 3.5 | 0.5 | 33.4 | 42.1 | 19.5 | 5.0 | 8.6 | 30.3 | 38.9 | 22.3 | 1.0 | 9.7 | 30.6 | 58.7 |
| | 5-6 | 67.6 | 23.1 | 7.8 | 1.5 | 21.6 | 34.4 | 31.0 | 13.0 | 5.4 | 18.9 | 37.6 | 38.1 | 1.3 | 5.9 | 23.8 | 69.1 |
| | 6-7 | 68.8 | 25.8 | 5.2 | 0.2 | 26.4 | 45.9 | 26.2 | 1.6 | 8.2 | 33.3 | 49.8 | 8.7 | 1.6 | 11.4 | 51.5 | 35.6 |
| | 7-8 | 58.1 | 30.0 | 11.1 | 0.8 | 17.6 | 35.8 | 39.5 | 7.1 | 3.0 | 14.3 | 49.1 | 33.5 | 0.3 | 2.3 | 28.2 | 69.3 |
| | 8-9 | 79.8 | 16.3 | 3.4 | 0.5 | 40.8 | 37.5 | 17.9 | 3.8 | 11.5 | 29.8 | 35.6 | 23.1 | 1.9 | 8.3 | 28.7 | 61.1 |
| | 9-10 | 81.9 | 14.2 | 3.6 | 0.3 | 38.7 | 38.3 | 21.0 | 2.0 | 13.3 | 32.5 | 43.0 | 11.2 | 3.9 | 12.6 | 45.2 | 38.3 |
| Science | 3-4 | 60.9 | 28.5 | 9.5 | 1.1 | 19.2 | 40.6 | 33.1 | 7.2 | 6.0 | 24.6 | 48.3 | 21.1 | 1.2 | 6.9 | 31.5 | 60.5 |
| | 4-5 | 67.2 | 25.5 | 6.8 | 0.5 | 23.5 | 43.1 | 29.0 | 4.4 | 6.3 | 25.0 | 48.0 | 20.8 | 0.8 | 5.5 | 32.7 | 61.0 |
| | 5-6 | 71.1 | 21.5 | 7.0 | 0.5 | 24.7 | 37.7 | 32.5 | 5.1 | 4.9 | 18.4 | 49.3 | 27.4 | 0.4 | 2.8 | 25.3 | 71.4 |
| | 6-7 | 80.7 | 15.5 | 3.2 | 0.6 | 39.8 | 36.8 | 19.5 | 3.9 | 10.4 | 23.7 | 41.0 | 24.9 | 1.1 | 4.8 | 22.1 | 72.0 |
| | 7-8 | 75.9 | 18.1 | 5.4 | 0.6 | 31.3 | 37.0 | 26.9 | 4.9 | 8.7 | 23.2 | 43.9 | 24.1 | 1.4 | 4.7 | 24.6 | 69.3 |
| | 8-9 | 82.9 | 14.4 | 2.6 | 0.2 | 42.5 | 38.9 | 16.4 | 2.3 | 13.9 | 33.2 | 38.4 | 14.5 | 2.0 | 9.0 | 30.8 | 58.1 |
| | 9-10 | 83.7 | 12.9 | 2.8 | 0.5 | 35.1 | 38.0 | 22.5 | 4.4 | 8.7 | 24.2 | 43.3 | 23.8 | 1.5 | 4.8 | 23.0 | 70.7 |

# 14.5 Measurement Error of Growth Scores

Measures of individual student growth, including SGPs and gain scores, are subject to measurement error (Wells, Sireci, & Bahry, 2014; McCaffrey, Castellano, & Lockwood, 2015). This means that a student's actual growth in academic achievement may be different from what is represented by their SGP or gain score. The SEM of gain scores is a function of the SEMs of the test score components:

$$\text{SEM}(\text{Gain}) = \text{SEM}(Y - X) = \sqrt{\text{SEM}_Y^2 + \text{SEM}_X^2}$$

where Y is the current year's test score and X is the prior year's test score. Thus, the SEM of gain scores is larger than the SEM of the component test scores. ACT Aspire subject test scores generally have SEM values between 2 and 3, so the SEMs of the gain scores are generally between 2.8 and 4.2. Mean gain scores (Table 14.8) are generally small relative to the SEM of gain scores, and negative gain scores may be observed, due in part to measurement error.

Because of their relatively high SEM, gain scores cannot be used to measure a student's true growth with high precision. Neither SGPs nor gain scores should be used as the sole indicator of a student's academic progress over one year. Instead, SGPs and gain scores can complement other evidence of learning such as teacher observation, performance on homework and quizzes, unit tests, and interim assessments.

For classrooms, schools, districts, states, and other user-defined groups, individual growth scores can be aggregated. The percentage of students in each growth category (low, average, or high) is included in group reports. Other aggregate growth measures, such as the mean or median SGP, can be calculated using the SGP data reported in the student performance file. The standard error of an aggregate growth score (e.g., mean SGP or mean gain score) decreases with the group sample size, so it is often much smaller than the SEM of an individual growth score. While individual growth scores cannot be used to measure a student's true growth with high precision, aggregate growth scores offer greater precision for supporting inferences about a group's growth.

# 14.6 Aggregate Growth Scores for Research and Evaluation

One of the secondary uses of ACT Aspire scores is evaluating school and program effectiveness (see Chapter 12). ACT Aspire growth measures can support research, evaluation, and indicators used for accountability. Before using ACT Aspire for program evaluation, a content review is critical to ensure that ACT Aspire measures important outcomes of the program. For example, a district could use the mean SGP of 10th-grade English students as one measure of the effectiveness of a new 10th-grade English curriculum. Before implementation, ACT Aspire content should be reviewed against the intended outcomes of the program to evaluate its appropriateness for measuring curriculum effectiveness.

The mean SGP can be used to identify growth differences across districts, schools, classrooms, or other groups. However, this alone does not explain reasons for the growth differences. When comparing mean SGPs across groups, it is important to consider whether differences in the student composition of the groups could explain the group differences. For example, a school serving economically disadvantaged students might be expected to have lower mean SGP than a school serving students from affluent families. Section 14.2.2 provides more information on subgroup differences in SGPs.

## 14.6.1 Normative Data for School Mean SGPs

Measures of aggregate growth include the mean and median SGP. Research suggests that the mean SGP may be more efficient, align better with expected values, and tolerate scale transformations better than the median SGP (Castellano & Ho, 2015). We now examine distributions of school mean SGPs (MGPs) by subject and grade. To derive summary statistics of distributions of school MGPs, the following steps were taken:

1. Using ACT Aspire longitudinal data collected through spring 2018, SGP values were assigned using the 2018 version of the SGPs (used for reporting in the 2018–2019 academic year).
2. For each combination of school, subject, grade, and academic year, the MGP was calculated.
3. For each school, subject, and grade, the MGP for the academic year with the largest sample size with $n \geq 10$ was retained.
4. For each subject and grade, the mean and standard deviation of school MGP was calculated. The sample size ($n$ = number of schools), mean MGP, and standard deviation of MGP are reported in Table 14.10. Most of the mean MGP values in Table 14.10 are below 50, the theoretical SGP mean. This is likely because the general sample of ACT Aspire examinees had slightly lower growth than the examinees included in the stratified random sample used to derive the SGPs.
5. For each subject and grade, selected percentiles (5, 10, 25, 75, 90, 95) of the MGP distribution were estimated using normal distribution quantiles corresponding to the mean and standard deviation. The percentile estimates are also reported in Table 14.10.

The results presented in Table 14.10 can be used to help interpret a school's MGP values relative to other schools. For example, for grade 5-6, a mathematics MGP of 40 is very close to the 25th percentile of the school MGP distribution. Conversely, a mathematics MGP of 60 is just below the 90th percentile.

It is important to note that the distribution of school MGP is affected by the size of the group. When MGP is based on a smaller sample size, it is less precise, and extreme MGP values are more likely to result.

**Table 14.10. Distributions of School MGPs by Subject and Grade**

| Subject | Grade Pair | N | Mean | SD | Percentile 5 | 10 | 25 | 75 | 90 | 95 |
|---|---|---|---|---|---|---|---|---|---|---|
| English | 3–4 | 901 | 47.2 | 8.3 | 33.6 | 36.6 | 41.6 | 52.8 | 57.8 | 60.8 |
| | 4–5 | 898 | 47.8 | 7.8 | 35.1 | 37.9 | 42.6 | 53.1 | 57.8 | 60.6 |
| | 5–6 | 676 | 48.4 | 7.9 | 35.3 | 38.2 | 43.0 | 53.7 | 58.5 | 61.4 |
| | 6–7 | 697 | 47.5 | 8.0 | 34.3 | 37.2 | 42.1 | 52.9 | 57.8 | 60.8 |
| | 7–8 | 756 | 48.0 | 7.3 | 36.0 | 38.6 | 43.1 | 52.9 | 57.4 | 60.0 |
| | 8–9 | 519 | 48.6 | 8.5 | 34.6 | 37.7 | 42.8 | 54.3 | 59.5 | 62.6 |
| | 9–10 | 1,273 | 50.1 | 7.0 | 38.6 | 41.1 | 45.4 | 54.9 | 59.2 | 61.7 |
| Mathematics | 3–4 | 1,305 | 47.0 | 9.7 | 31.1 | 34.6 | 40.5 | 53.5 | 59.3 | 62.9 |
| | 4–5 | 1,295 | 46.6 | 9.7 | 30.7 | 34.2 | 40.1 | 53.1 | 59.0 | 62.5 |
| | 5–6 | 999 | 48.0 | 10.6 | 30.6 | 34.4 | 40.8 | 55.1 | 61.5 | 65.4 |
| | 6–7 | 970 | 46.9 | 9.5 | 31.3 | 34.8 | 40.5 | 53.3 | 59.1 | 62.6 |
| | 7–8 | 1,007 | 47.4 | 9.5 | 31.7 | 35.2 | 41.0 | 53.9 | 59.6 | 63.1 |
| | 8–9 | 532 | 48.5 | 8.8 | 33.9 | 37.1 | 42.5 | 54.4 | 59.8 | 63.0 |
| | 9–10 | 1,277 | 49.8 | 7.5 | 37.5 | 40.2 | 44.7 | 54.8 | 59.4 | 62.1 |
| Reading | 3–4 | 1,306 | 47.5 | 7.6 | 35.0 | 37.8 | 42.4 | 52.7 | 57.3 | 60.1 |
| | 4–5 | 1,295 | 47.6 | 7.7 | 35.1 | 37.8 | 42.5 | 52.8 | 57.4 | 60.2 |
| | 5–6 | 999 | 49.0 | 8.3 | 35.3 | 38.3 | 43.4 | 54.6 | 59.6 | 62.7 |
| | 6–7 | 968 | 47.0 | 8.2 | 33.5 | 36.5 | 41.5 | 52.5 | 57.5 | 60.5 |
| | 7–8 | 1,005 | 47.6 | 7.8 | 34.8 | 37.6 | 42.4 | 52.9 | 57.6 | 60.5 |
| | 8–9 | 527 | 48.9 | 8.6 | 34.7 | 37.8 | 43.0 | 54.7 | 59.9 | 63.1 |
| | 9–10 | 1,269 | 50.5 | 8.0 | 37.3 | 40.2 | 45.1 | 55.9 | 60.8 | 63.7 |
| Science | 3–4 | 962 | 47.7 | 8.2 | 34.2 | 37.2 | 42.1 | 53.2 | 58.1 | 61.1 |
| | 4–5 | 1,012 | 46.2 | 9.2 | 31.1 | 34.4 | 40.0 | 52.3 | 57.9 | 61.2 |
| | 5–6 | 780 | 47.7 | 9.0 | 32.9 | 36.2 | 41.6 | 53.8 | 59.2 | 62.5 |
| | 6–7 | 783 | 46.9 | 8.6 | 32.7 | 35.8 | 41.1 | 52.7 | 58.0 | 61.1 |
| | 7–8 | 815 | 47.8 | 8.4 | 34.0 | 37.1 | 42.2 | 53.5 | 58.6 | 61.7 |
| | 8–9 | 516 | 49.0 | 8.3 | 35.4 | 38.4 | 43.4 | 54.5 | 59.6 | 62.6 |
| | 9–10 | 1,252 | 50.8 | 7.9 | 37.9 | 40.7 | 45.5 | 56.1 | 60.8 | 63.7 |

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# Appendix A

# ACT Aspire Grade Level Targets for Writing and English

## Grade 3

By the end of third grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length from sentences to multiple paragraphs. When writing, they show growing awareness of audience and use strategies to approach the writing task. They understand that the writing process includes planning, drafting, revising, and publishing, and they move through these stages with some independence. They develop ideas that are mostly relevant to the task and provide some supporting details, establish a simple organization with transitions between sentences and some paragraphing, and use familiar language to communicate ideas clearly. They write with some control of spelling, grammar, and punctuation, and use some variation in sentence structure. Writing shows an emerging sense of voice, and students recognize opportunities for formal and informal tone. With feedback and sometimes independently, they revise their writing, often focusing on local errors in grammar, punctuation, capitalization, and spelling. With prompting, they make choices about more global revisions to strengthen their writing.

**Students in grade 3 can do the following:**

**Topic Development**

- Use a word or phrase to accomplish a straightforward rhetorical purpose or effect
- Evaluate whether a text accomplishes a straightforward rhetorical purpose

**Organization**

- Use an introductory or concluding sentence that logically relates to the main idea of the paragraph
- Use transition words and phrases to link sentences
- Organize elements in a sentence logically

**Expressing Ideas Clearly**

- Use descriptive language
- Use words to express simple relationships within sentences
- Recognize obvious redundancy and unnecessary wording
- Use familiar words appropriate to the content and context of the text

**Style**

- Distinguish between contexts calling for formal and informal language

**Sentence Structure**

- Avoid obvious errors in coordination and subordination
- Use a coordinating conjunction to join two short, simple sentences

**Usage**

- Correctly use idiomatic language
- Correctly form and use regular, irregular, plural, and possessive nouns and pronouns
- Correctly form and use regular and irregular verbs in various tenses, ensuring subject-verb agreement
- Correctly form and use modifiers (including adjectives, adverbs, and prepositional phrases), ensuring that the correct degree (comparative, superlative) is used
- Recognize and correct errors in pronoun-antecedent agreement

**Punctuation and Capitalization**

- Capitalize proper names
- Correctly punctuate simple sentences with periods, question marks, and exclamation points
- Use commas before coordinating conjunctions
- Use apostrophes to indicate possession when the possessive relationship is clear

# Grade 4

By the end of fourth grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length from sentences to multiple paragraphs. When writing, they show growing awareness of audience and knowledge of text types, and they increasingly adjust strategies to approach the writing task. They understand that the writing process includes planning, drafting, revising, and publishing, and they move through these stages with some independence. They develop ideas that are mostly relevant to the task and provide supporting details, establish a simple organization with transitions between sentences and paragraphs focused on a topic, and increasingly apply knowledge of language to communicate ideas accurately, with word choices that are somewhat precise. They write with generally accurate spelling, grammar, usage, and punctuation, and some variation in sentence structure. They demonstrate an emerging sense of voice and can adjust tone for formal and informal contexts. With feedback and sometimes independently, they revise their writing, often focusing on local errors in grammar, punctuation, capitalization, and spelling. With prompting, they make choices about more global revisions to strengthen their writing.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 4 can do the following:**

**Topic Development**

- Use a word or phrase to achieve a specific rhetorical purpose or effect (e.g., provide support for a claim)
- Incorporate content that is relevant to the topic and focus of a paragraph
- Evaluate whether a text accomplishes a straightforward rhetorical purpose

**Organization**

- Use an effective introductory or concluding sentence in a short paragraph
- Use transition words or phrases appropriate to the content and genre
- Organize sentences within paragraphs logically

**Expressing Ideas Clearly**

- Use language that conveys simple ideas and descriptions precisely and vividly
- Use precise words to express relationships within sentences
- Recognize obvious redundancy and unnecessary wording
- Use some general academic words in appropriate contexts
- Use language that concisely communicates ideas, avoiding redundancy within sentences

**Style**

- Distinguish between contexts calling for formal and informal language

**Sentence Structure**

- Avoid obvious sentence fragments and run-ons, including comma splices
- Avoid errors in coordination, subordination, and parallelism
- Use coordinating conjunctions to combine multiple short sentences

**Usage**

- Correctly use idiomatic language
- Distinguish frequently confused words
- Correctly form and use regular, irregular, plural, and possessive nouns and pronouns
- Correctly form and use verbs in various tenses and use modal auxiliary verbs appropriate to the context
- Correctly form and use modifiers (including adjectives, adverbs, and prepositional phrases), ensuring that the correct degree (comparative, superlative) is used
- Recognize and correct errors in pronoun-antecedent agreement

**Punctuation and Capitalization**

- Apply conventions of capitalization for multi-word proper nouns
- Correctly punctuate short sentences with coordinating conjunctions and paragraphs with dialogue
- Use commas before coordinating conjunctions
- Use apostrophes to indicate possession when the possessive relationship is clear

# Grade 5

By the end of fifth grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that are often multiple paragraphs in length. When writing, they show growing awareness of audience and knowledge of text types, and they increasingly adjust strategies to approach the writing task. They understand that the writing process includes planning, drafting, revising, and publishing, and they move through these stages with increasing awareness and independence. They develop ideas that are mostly relevant to the task and provide effective supporting details, drawing on their experiences as well as from print and digital sources. Their texts have a simple organization with clear transitions between sentences. Paragraphs are largely focused on a topic. Students use their knowledge of language to communicate ideas, making thoughtful word choices. They write with generally accurate spelling, grammar, and punctuation, and use some variation in sentence structure. Students use a somewhat consistent voice and tone that is appropriate for the task. With feedback and sometimes independently, they revise their writing, often focusing on local errors in grammar, punctuation, capitalization, and spelling. With prompting, they make choices about more global revisions to strengthen their writing.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 5 can do the following:**

**Topic Development**

- Use a word or phrase to achieve a specific rhetorical purpose or effect (e.g., provide support for a claim)
- Incorporate content that is relevant to the topic of a paragraph
- Evaluate whether a text accomplishes a specific rhetorical purpose

**Organization**

- Use effective introductory, concluding, and transition sentences to emphasize relationships within and between paragraphs
- Use effective transition words or phrases to connect ideas in two adjacent sentences and to connect a new paragraph to ideas in the previous paragraph
- Organize sentences in a paragraph to complete or connect key ideas

**Expressing Ideas Clearly**

- Use language that conveys simple ideas and descriptions precisely and vividly
- Use precise words to express relationships effectively within and between sentences
- Remove redundant or unnecessary words
- Use general academic and some domain-specific words with increasing accuracy in appropriate contexts
- Use language that concisely communicates ideas, avoiding redundancy within sentences

**Style**

- Use words and phrases appropriate to level of text formality

**Sentence Structure**

- Avoid obvious sentence fragments and run-ons, including comma splices
- Avoid errors in coordination, subordination, and parallelism
- Maintain consistent verb tense within a paragraph
- Use coordinating and subordinating conjunctions to create different sentence structures

**Usage**

- Correctly use idiomatic language
- Distinguish frequently confused words
- Correctly form and use regular, irregular, plural, and possessive nouns and pronouns
- Correctly form and use verbs in various tenses and use modal auxiliary verbs appropriate to the context
- Correctly form and use modifiers (including adjectives, adverbs, and prepositional phrases), ensuring that the correct degree (comparative, superlative) is used
- Recognize and correct errors in pronoun-antecedent agreement

**Punctuation and Capitalization**

- Apply conventions of capitalization
- Correctly punctuate short sentences with coordinating conjunctions and paragraphs with dialogue
- Use commas after long introductory phrases and to separate items in series
- Use an apostrophe to correctly form the possessive of an irregular plural noun

# Grade 6

By the end of sixth grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length. Their writing supports learning across subjects. When writing, they show growing awareness of audience and knowledge of text types, and they increasingly adjust strategies to approach the writing task. They have a clear understanding of different stages in the writing process, including planning, drafting, revising, and publishing, and they move through stages with increasing awareness of the specific writing task and purpose. They develop ideas that are relevant to the task and provide effective, carefully selected supporting details, drawing on their experiences as well as from print and digital sources. They use different text structures to organize their writing, and paragraphs are focused with smooth transitions between sentences. Students increasingly use knowledge of language to communicate ideas and make precise word choices. They write with accurate spelling, grammar, and punctuation, and use some variation in sentence structure. Students use a somewhat consistent voice and tone that is appropriate for the task. They revise their writing independently, correcting errors in grammar, punctuation, capitalization, and spelling as well as more global issues.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 6 can do the following:**

**Topic Development**

- Use a word or phrase to accomplish a specific rhetorical purpose (e.g., select most convincing support for a claim)
- Incorporate content that is relevant to the topic of a paragraph and to the text as a whole
- Evaluate whether a text accomplishes a specific rhetorical purpose

**Organization**

- Use effective introductory, concluding, and transition sentences to emphasize relationships within and between paragraphs
- Use effective transition words or phrases to logically connect disparate ideas within a paragraph or contrast two sentences in a text
- Organize sentences and paragraphs to ensure a logical progression of ideas

**Expressing Ideas Clearly**

- Make precise word choices based on the context of multiple sentences
- Use precise words to express relationships effectively within and between sentences
- Revise words and phrases to avoid redundancy or unnecessary words
- Use general academic and some domain-specific words with increasing accuracy in appropriate contexts
- Use language that concisely communicates ideas, avoiding redundancy and unnecessary words within paragraphs

**Style**

- Maintain consistency in overall style and tone

**Sentence Structure**

- Avoid sentence fragments and run-ons, including comma splices
- Avoid errors in coordination, subordination, and parallelism
- Maintain consistent verb tense within a paragraph

- Use the correct pronoun number and person based on the context of the sentence or paragraph
- Use a variety of sentence structures

**Usage**

- Correctly use idiomatic language
- Distinguish frequently confused words
- Use the correct pronoun in more complex situations, such as when the antecedent is plural

**Punctuation**

- Correctly punctuate longer sentences and paragraphs
- Use commas to set off nonrestrictive clauses in sentences and to separate two adjectives that describe the same noun
- Use an apostrophe to correctly form the possessive of an irregular plural noun

# Grade 7

By the end of seventh grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length. Their writing supports learning across subjects. When writing, they increasingly determine audience, text type, and strategies to select an effective approach, sometimes blending text types to communicate effectively. They understand different stages in the writing process, including planning, drafting, revising, and publishing, and they move through stages flexibly with awareness of the specific writing task and purpose. They develop ideas that are relevant to the task and provide effective, carefully selected supporting details, drawing on their own experiences and using different strategies to acquire information from print and digital sources. They apply their knowledge of text structures to organize their writing. Paragraphs have a clear focus and are cohesive, and introduction and concluding sentences establish connections between paragraphs and across the text. Students use their growing knowledge of literary and academic language to communicate complex ideas. Spelling, grammar, and punctuation are largely accurate, and sentence structure and length vary. They write with a consistent voice and tone that is appropriate for the task. Students revise their writing independently, correcting errors in grammar, punctuation, capitalization, and spelling as well as more global issues.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 7 can do the following:**

**Topic Development**

- Use a word or phrase to accomplish a specific rhetorical purpose (e.g., select most convincing support for a claim)
- Incorporate content that is relevant to the topic of a paragraph and to the test as a whole
- Evaluate whether a text accomplishes a specific rhetorical purpose which may be multifaceted

**Organization**

- Use effective introductory, concluding, and transition sentences that maintain focus without redundancy
- Use effective and precise transition words or phrases to logically connect ideas across paragraphs
- Organize sentences and paragraphs to ensure a logical progression of ideas

**Expressing Ideas Clearly**

- Make precise word choices based on the context of the paragraph or text as a whole
- Use words or phrases to express subtle relationships between ideas within a sentence
- Revise words, phrases, and sentences to avoid redundancy or unnecessary words across multiple sentences
- Use domain-specific words or phrases, considering both connotative and denotative meanings, in appropriate contexts
- Use language that concisely communicates ideas, avoiding redundancy and unnecessary words across paragraphs

**Style**

- Maintain consistency in overall style and tone

**Sentence Structure**

- Avoid sentence fragments and run-ons, including comma splices
- Avoid sentence formation errors, including issues with coordination, subordination, and parallelism
- Maintain consistent verb tense across multiple paragraphs
- Use the correct pronoun number and person based on the context of the sentence or paragraph in increasingly long or complex paragraphs
- Use a variety of sentence structures

**Usage**

- Correctly use idiomatic language
- Distinguish frequently confused words
- Use correct pronouns in more complex situations, such as when the antecedent is plural

**Punctuation**

- Correctly punctuate longer sentences and paragraphs
- Use commas to separate multi-word phrases in a series
- Use the appropriate plural, possessive, or singular noun form when the context is complex

# Grade 8

By the end of eighth grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length. Their writing supports learning across subjects and demonstrates an understanding of different disciplinary conventions and text types. When writing, they use awareness of audience, text types, and strategies to select an effective approach, sometimes blending text types to communicate effectively. They understand that the writing process is flexible and recursive, and they use planning, drafting, revising, and publishing stages with awareness of the specific writing task and purpose. They generate and develop a wide range of ideas that are relevant to the task and provide effective supporting details and examples, drawing on their own experience and using different strategies to acquire information from print and digital sources. If writing with sources, they attribute ideas and quotations to the authors. They apply knowledge of text structures to organize writing, modeling their own work on examples that they have read and moving away from formulaic writing. They maintain a clear focus with transition words and sentences that effectively link ideas within paragraphs and throughout the text. Introductions and conclusions enhance unity and coherence. Students use literary, academic, and some domain-specific language to communicate complex ideas accurately and precisely. Spelling, grammar, punctuation, and usage are accurate, and students use a variety of sentence structures, exploring complex sentences and variations that produce stylistic effects. They write with a consistent voice and tone that is appropriate to the task. They revise their writing independently, considering audience and purpose.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 8 can do the following:**

**Topic Development**

- Use a word or phrase to accomplish a specific rhetorical purpose (e.g., select most convincing support for a claim)
- Incorporate content that contributes to the overall purpose, unity, and focus of the text, ensuring a logical development and progression of ideas
- Evaluate whether a text accomplishes a specific rhetorical purpose which may be multifaceted

**Organization**

- Use effective introductory, concluding, and transition sentences to emphasize relationships within and between longer, more complex paragraphs
- Use effective and precise transition words or phrases to logically connect ideas across paragraphs
- Organize sentences and paragraphs to ensure the logical progression of ideas within and across paragraphs

**Expressing Ideas Clearly**

- Use words and phrases, considering both connotative and denotative meaning, to enhance a specific rhetorical effect in a sentence and within a text as a whole
- Use words or phrases to express subtle relationships between ideas within a sentence

- Revise words, phrases, and sentences to avoid redundancy or unnecessary words when the context is more complex
- Use familiar general academic and domain-specific words and phrases skillfully and appropriately
- Use language that concisely communicates ideas, avoiding redundancy and unnecessary words across the entire text

**Style**

- Maintain consistent stylistic phrasing within a sentence or paragraph for rhetorical purposes

**Sentence Structure**

- Avoid sentence fragments and run-ons, including comma splices
- Avoid subtle subordination errors between clauses, as well as issues with coordination, parallelism, and misplaced modifiers
- Avoid inappropriate shifts in verb tense, aspect, and voice
- Use the correct pronoun number and person based on the context of the sentence or paragraph in increasingly long or complex paragraphs
- Vary sentence structure to minimize repetition

**Usage**

- Use appropriate idiomatic language, including prepositions, consistently in a range of contexts
- Distinguish frequently confused words
- Use the correct pronoun in more complex situations, such as when a pronoun is the subject of a sentence and there is text between the subject and verb

**Punctuation**

- Apply conventions of punctuation with increasingly complex text that might include colons, semicolons, or dashes to indicate sharp breaks in sentences
- Use commas to separate multi-word phrases in a series
- Use apostrophes to form possessive singular or plural nouns when the structure of the sentence makes it difficult to determine if the possessive form is required

# Early High School (Grades 9 and 10)

By the end of tenth grade, students can produce writing in print and digital media for a range of purposes, audiences, and contexts. They write narrative, informational, and persuasive texts that vary in length. Their writing supports learning across subjects and demonstrates a growing understanding of different disciplinary conventions and text types. When writing, they use awareness of audience, text types, and strategies to select an effective approach, adjusting voice and tone to accomplish a complex purpose. Students understand that the writing process is flexible and recursive, and they use planning, drafting, revising, and publishing stages with awareness of the specific writing task and purpose; they increasingly see the value of planning techniques. They generate and develop a wide range of ideas that are relevant to the task and audience. They provide effective supporting details and examples, drawing on their own experiences and using different strategies to acquire information from print and digital sources. If writing with sources, they understand and observe citation conventions. They apply knowledge of text structures to organize their writing, adapting examples from texts that they find effective. Paragraphs have a clear and sometimes complex focus and a strong internal cohesion, and transition words and sentences effectively link, sequence, and signpost ideas across the text. Introductions and conclusions enhance the overall clarity and effect of the writing. Students use a range of literary, academic, and domain-specific language to communicate complex ideas accurately and precisely. Spelling, grammar, punctuation, and usage are generally accurate. Students use a variety of sentence structures and explore complex sentences and variations that produce stylistic effects. They revise their writing independently, considering audience and purpose.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in early high school can do the following:**

**Topic Development**

- Use a word, phrase, or sentence to accomplish a sophisticated rhetorical purpose (e.g., express a nuanced idea or specific emotions)
- Incorporate content that contributes to the overall purpose, unity, and focus of the text, ensuring a logical development and progression of ideas
- Evaluate whether a text accomplishes a complex or multifaceted rhetorical purpose

**Organization**

- Use effective introductory, concluding, and transition sentences to emphasize subtle relationships and signal shifts in focus within and between longer, more complex paragraphs
- Use effective and precise transition words or phrases to emphasize complex relationships
- Organize sentences and paragraphs to ensure the logical progression of ideas and to develop the purpose of the text as a whole

**Expressing Ideas Clearly**

- Use words and phrases, considering both connotative and denotative meaning, to precisely express and build on ideas throughout a text
- Use words or phrases to precisely express relationships between two complex, related ideas within a sentence
- Revise words, phrases, and sentences to avoid redundancy or unnecessary words when the context is more complex
- Use familiar general academic and domain-specific words and phrases skillfully and appropriately
- Use language that concisely communicates ideas, avoiding redundancy and unnecessary words across the entire text

**Style**

- Maintain consistent stylistic phrasing throughout a text for rhetorical purposes

**Sentence Structure**

- Avoid sentence fragments and run-ons, including comma splices
- Avoid subtle subordination errors between clauses as well as issues with coordination, parallelism, and misplaced modifiers
- Avoid inappropriate shifts in verb tense, aspect, voice, and mood
- Use the correct pronoun number and person based on the context of the paragraph or preceding paragraphs
- Vary sentence structure and length to minimize repetition and enhance a specific rhetorical effect

**Usage**

- Use appropriate idiomatic language, including prepositions, consistently in a range of contexts
- Distinguish frequently confused words
- Use correct pronouns in more complex situations, such as when a pronoun is the subject of a sentence and there is text between the subject and verb

**Punctuation**

- Apply conventions of punctuation with text that is conceptually or structurally complex
- Uses commas skillfully to achieve a specific rhetorical effect
- Use apostrophes to form possessive singular or plural nouns when the structure of the sentence makes it difficult to determine if the possessive form is required

Appendix B

# ACT Aspire Grade Level Targets for Reading

## Grade 3

By the end of third grade, students have read a variety of narrative and informational texts across the ACT *basic* and *straightforward* text complexity levels. Students have read all genres of literary and informational texts, including print and digital sources, on a range of topics. The texts vary in length, have clear structures related to their purposes, and include some unfamiliar academic and domain-specific language. Students apply foundational reading skills to process text as they develop fluency, accuracy, and independence. When reading in class and independently, students practice strategies to understand and think critically about clearly stated information and ideas in the texts. They show a growing awareness of text purposes and basic organizational structures, begin to draw local inferences, work out the meaning of unfamiliar words, read some longer and more complex sentences, and sometimes recognize when their understanding breaks down.

# Text Complexity Levels

**Basic**

Basic texts have a simple purpose and use primarily short and basic sentences. Vocabulary is mostly familiar and contemporary, with some polysyllabic words and domain-specific language. Most objects and events are concrete. Concepts are few, clear, and often repeated. Visual elements, including pictures and graphics, may have some informational content and support understanding of the text.

Informational texts clearly focus on one subject and use a simple structure with basic transitions.

Literary texts are primarily literal; plots are in chronological order, and conflicts are simple and usually external. These texts have a single narrator and generally flat characters. These texts may include a few instances of simple nonliteral language and literary devices such as simple similes and metaphors.

**Straightforward**

Straightforward texts have a clear purpose and organization, explicit transitions, and a variety of sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferential reading and contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and may assume broad content knowledge.

Literary texts have a single narrator, and conflicts are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

**Students in grade 3 can do the following:**

**Close Reading**

- Demonstrate understanding of what the text says explicitly
- Make simple inferences based on the text
- Describe characters (including physical traits, motivations, or feelings)
- Compare and contrast the characters, settings, and plots of multiple stories
- Compare and contrast the information presented in two texts on the same topic

**Main Ideas and Themes**

- Determine the main ideas and themes of texts
- Summarize informational texts focused on a single, concrete topic
- Summarize stories and other narratives with simple, external conflicts and plots primarily in chronological order or with simple, heavily signaled flashbacks
- Compare and contrast the main ideas or themes of two or more texts

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases from mostly familiar context
- Determine the meaning of simple, nonliteral language and literary devices, such as simple similes and metaphors, from context
- Analyze how word choice affects meaning

**Text Structure**

- Use text features to identify the purpose and function of a text overall and specific text portions
- Identify parts of a story and describe how they relate to its overall theme or lesson
- Compare literary and informational texts on the same topic and describe text features

**Purpose and Point of View**

- Determine an author's purpose in a text that has a straightforward purpose
- Distinguish an author's point of view from one's own point of view
- Identify obvious bias and stereotypes
- Distinguish a narrator's point of view from the author's point of view or other characters' points of view
- Compare and contrast texts with different purposes related to the same topic

**Arguments**

- Identify an author's explicit claims
- Distinguish between fact and opinion

# Grade 4

By the end of fourth grade, students have read a variety of narrative and informational texts across the ACT *basic* and *straightforward* text complexity levels, with increased emphasis on texts at the upper end of this range. Students have read all genres of literary and informational texts, including print and digital sources on a range of topics. The texts vary in length, have clear structures related to their purposes, and include some unfamiliar academic and domain-specific language. Having consolidated decoding and other foundational skills, students process text with increasing fluency, accuracy, and independence. When reading in class and independently, students practice strategies to understand and think critically about clearly stated information and ideas in the texts, making connections to their own experiences. They show a growing awareness of text purposes and how these relate to basic organizational structures, draw some local inferences, work out the meaning of unfamiliar words using more than one approach, and read a variety of sentence structures. They monitor their understanding with some confidence and adjust their strategy when understanding breaks down.

# Text Complexity Levels

**Basic**

Basic texts have a simple purpose and use primarily short, basic sentences. Vocabulary is mostly familiar and contemporary, with some polysyllabic words and domain-specific language. Most objects and events are concrete. Concepts are few, clear, and often repeated. Visual elements, including pictures and graphics, may have some informational content and support understanding of the text.

Informational texts clearly focus on one subject and use a simple structure with basic transitions.

Literary texts are primarily literal; plots are in chronological order, and conflicts are simple and usually external. These texts have a single narrator and generally flat characters. These texts may include a few instances of simple nonliteral language and literary devices such as simple similes and metaphors.

**Straightforward**

Straightforward texts have a clear purpose and organization with explicit transitions and include a variety of sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferences and may contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and may support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and may assume broad content knowledge.

Literary texts have a single narrator, and conflicts are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 4 can do the following:**

**Close Reading**

- Refer to details and examples when explaining what the text says explicitly and when drawing inferences from the text
- Explain relationships between two or more individuals, events, or ideas in a text
- Use specific details from a story, such as a characters’ words, thoughts, and actions, to describe a character, setting, or event
- Compare and contrast the characters, settings, and plots of multiple stories
- Integrate information from two texts on the same topic to develop more knowledge about the topic

**Main Ideas and Themes**

- Determine the main ideas and themes of texts and identify key details that support them
- Summarize informational texts which may include more abstract concepts and assume some prior content knowledge
- Summarize stories and other narrative texts with simple, external conflicts and plots primarily in chronological order or with simple, heavily signaled flashbacks
- Compare and contrast the main ideas or themes of two or more texts

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases from mostly familiar context
- Determine the meaning of simple, nonliteral language and literary devices, such as simple similes and metaphors, from context
- Analyze how language, including word choice, sets a formal or informal tone

**Text Structure**

- Describe the purpose or function of paragraphs or sections in an informational text as they relate to chronology, comparison, and cause and effect relationships
- Explain the purpose or function of plot elements within a story
- Compare and contrast the use of figurative language and literary devices in literary and informational books on the same topic

**Purpose and Point of View**

- Determine an author's purpose in a text that has a straightforward purpose
- Distinguish between multiple perspectives in a text
- Identify simple persuasive techniques
- Identify the point of view from which different stories are narrated, including the difference between first and third person narrators
- Compare and contrast texts with different purposes related to the same topic

**Arguments**

- Identify an author's explicit claims and infer an implied claim
- Distinguish between fact and opinion
- Compare and contrast how two or more authors use different evidence to support the same argument

## Grade 5

By the end of fifth grade, students have read a variety of narrative and informational texts across the ACT *basic*, *straightforward*, and *somewhat challenging* text complexity levels. Students have read all genres of literary and informational texts on a range of topics, and informational texts play a larger role in school learning. These texts include print and digital formats that vary in length. However, texts are longer than in lower grades, have a range of structures, are written for a wider range of purposes, and include some unfamiliar academic and domain-specific language. Students read with increasing fluency, accuracy, and independence. When reading in class and independently, students choose from a range of strategies to understand and think critically about clearly stated information and ideas in the texts, making connections to their own experiences. They show a growing awareness of texts' purposes and how these relate to organizational structures; draw inferences at the sentence and paragraph levels; work out the meaning of unfamiliar words, choosing from multiple approaches; and read a variety of sentence structures with increasing confidence. Students in grade 5 monitor their understanding with confidence and adjust their strategy when understanding breaks down.

# Text Complexity Levels

### Basic

Basic texts have a simple purpose and use primarily short, basic sentences. Vocabulary is mostly familiar and contemporary, with some polysyllabic words and domain-specific language. Most objects and events are concrete. Concepts are few, clear, and often repeated. Visual elements, including pictures and graphics, may have some informational content and support understanding of the text.

Informational texts clearly focus on one subject and use a simple structure with basic transitions.

Literary texts are primarily literal; plots are in chronological order, and conflicts are simple and usually external. These texts have a single narrator and generally flat characters. These texts may include a few instances of simple nonliteral language and literary devices such as simple similes and metaphors.

### Straightforward

Straightforward texts have a clear purpose and organization with explicit transitions and include a variety of sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferences and contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and assume broad content knowledge.

Literary texts have a single narrator, and conflicts are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

### Somewhat Challenging

Somewhat challenging texts have a clear purpose and organization, with variety in sentence styles and transitions. Vocabulary may include some general academic or uncommon words and phrases. These texts require inferences and contain abstract concepts as well as experiences and perspectives that may differ from those of the reader.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assumes everyday knowledge and content knowledge appropriate to the grade. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and nonlinear plots with clearly signaled shifts in point of view or time. Characters are dynamic and experience uncomplicated internal or external conflicts. These texts may include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter may be challenging, offering insights into people, situations, and events.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 5 can do the following:**

**Close Reading**

- Use accurately quoted or paraphrased evidence from texts to support inferences
- Explain relationships between two or more individuals, events, or ideas in a text
- Describe how a story's plot unfolds in a series of events
- Compare and contrast how the same event, person, or place is presented in fiction and nonfiction texts
- Integrate information from two texts on the same topic to develop more knowledge about the topic

**Main Ideas and Themes**

- Determine the main ideas or themes of texts and explain how key details support them
- Summarize texts with multiple perspectives and some abstract concepts
- Summarize stories and other narratives which may include dynamic characters with uncomplicated internal or external conflicts
- Compare and contrast texts' approaches to similar themes and topics

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases from context that may be less familiar or abstract
- Determine the meaning of figurative language and literary devices, such as a clearly established symbol, from context
- Analyze how language, including word choice, sets a formal or informal tone

**Text Structure**

- Demonstrate an understanding of different text structures, such as chronology, comparison, cause and effect, and problem and solution
- Explain how parts of a text contribute to the development of a topic, character, or theme
- Explain how the author's use of language and literary devices creates a specific effect on the reader or builds on reader understanding of different genres

**Purpose and Point of View**

- Determine an author's purpose in a text that may require inferences and may include abstract or unfamiliar concepts
- Recognize how point of view, perspective, and purpose influence the information about a topic
- Explain how an author uses stereotypes or persuasive techniques to influence audiences
- Describe how a narrator's point of view influences how events are described
- Compare and contrast texts with different purposes related to the same topic

**Arguments**

- Identify reasons and evidence used to support claims and to challenge counterclaims
- Distinguish between opinion and reasoned judgment
- Compare and contrast how two or more authors use different evidence to support the same argument

# Grade 6

By the end of sixth grade, students have read a variety of narrative and informational texts across the ACT *straightforward* and *somewhat challenging* text complexity levels. Students have read all genres of literary and informational texts on a range of topics, and informational texts compose the majority of their reading across school subjects. The texts include print and digital sources that vary considerably in length and format. Texts have a wide range of structures, are written for different purposes, and include unfamiliar academic and domain-specific language as well as literary devices. Students process text with increasing fluency, accuracy, and independence. They monitor their understanding and choose from a range of strategies to accomplish specific learning tasks. They understand and think critically about information and ideas that may be implicit in texts, and they increasingly integrate information across different texts on a given topic and draw connections to their own experiences. They show a growing awareness of text purposes and understand how these relate to text structures, draw increasingly accurate local and global inferences, work out the meaning of uncommon words using multiple approaches and reference materials, and confidently read a variety of sentence structures.

# Text Complexity Levels

**Straightforward**

Straightforward texts have a clear purpose and organization with explicit transitions and include a variety of sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferences and contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and assume broad content knowledge.

Literary texts have a single narrator, and conflicts are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

**Somewhat Challenging**

Somewhat challenging texts have a clear purpose and organization with varied sentence styles and transitions. Vocabulary may include some general academic or uncommon words and phrases. These texts require inferences and contain abstract concepts as well as experiences and perspectives that may differ from those of the reader.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume everyday knowledge and content knowledge appropriate to the grade. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and nonlinear plots with clearly signaled shifts in point of view or time. Characters are dynamic and experience uncomplicated internal or external conflicts. These texts may include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter may be challenging, offering insights into people, situations, and events.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 6 can do the following:**

**Close Reading**

- Use textual evidence to analyze what the text says explicitly and support inferences drawn from the text
- Analyze an individual, event, or idea in a text
- Explain how characters' traits influence their actions and contribute to the sequence of events
- Compare and contrast the characters, settings, and plots of multiple stories
- Synthesize information from two or more texts on the same topic to develop new ideas about that topic

**Main Ideas and Themes**

- Determine the main ideas or themes of texts that may offer insights into people, situations, and events and analyze their development over the course of the text
- Summarize a text that requires inferences, focusing on ideas from the text and avoiding personal opinion
- Summarize stories and other narratives that may include multiple narrators with clearly signaled shifts in point of view or time
- Compare and contrast texts in different formats or written for different purposes (e.g., literary fiction and historical narrative) on their approaches to similar themes and topics

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases from context clues that may be in other parts of the text
- Determine the meaning of figurative language and literary devices, such as symbolism or irony, from context
- Analyze the impact of a specific word choice on meaning and tone

**Text Structure**

- Analyze how a particular sentence or paragraph fits into the overall structure of a text and contributes to the development of ideas
- Analyze how a particular event or scene fits into the overall development of a theme, setting, or plot
- Identify how two or more texts provide contrasting information and explain how the new information influences each text

**Purpose and Point of View**

- Determine an author's purpose and explain how structure and content support that purpose
- Recognize how point of view, perspective, and purpose influence the information provided about a topic
- Identify subtle bias and stereotypes as well as sophisticated persuasive techniques
- Explain how an author develops the narrator's point of view in a text
- Analyze how two or more authors writing about the same topic select content to achieve different purposes

**Arguments**

- Identify reasons and evidence used to support claims and to challenge counterclaims and connect multiple claims to understand a broader argument
- Determine the validity of reasoned judgment which may be different from one's own
- Compare and contrast two or more texts that present conflicting arguments

# Grade 7

By the end of seventh grade, students have read a variety of narrative and informational texts across the ACT *straightforward* and *somewhat challenging* text complexity levels. Students have read all genres of literary and informational texts on a range of topics, and informational texts compose the majority of their reading across school subjects. The texts include print and digital sources that vary considerably in length and format. Texts have a wide range of structures, are written for several different purposes, and include unfamiliar academic and domain-specific language and literary devices. Students process text with increasing fluency, accuracy, and independence. They monitor their understanding and choose confidently and flexibly from several strategies to accomplish specific learning tasks. They understand and think critically about information and ideas that may be implicit in the texts or require careful interpretation, and they increasingly integrate information across different texts on a given topic and draw connections with their own experiences. They show a growing awareness of text purposes and understand how these relate to text structures, draw increasingly accurate local and global inferences, work out the meaning of uncommon words using multiple approaches and reference materials, and confidently read a variety of sentence structures.

## Text Complexity Levels

### Straightforward

Straightforward texts have a clear purpose and organization with explicit transitions and include a variety of sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferences and contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and assume broad content knowledge.

Literary texts have a single narrator, and conflicts are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

### Somewhat Challenging

Somewhat challenging texts have a clear purpose and organization with varied sentence structures and transitions. Vocabulary may include some general academic or uncommon words and phrases. These texts require inferences and contain abstract concepts as well as experiences and perspectives that may differ from those of the reader.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume everyday knowledge and content knowledge appropriate to the grade. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and nonlinear plots with clearly signaled shifts in point of view or time clearly signaled. Characters are dynamic and experience uncomplicated internal or external conflicts. These texts may include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter may be challenging, offering insights into people, situations, and events.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 7 can do the following:**

**Close Reading**

- Use textual evidence to analyze what the text says explicitly and support inferences drawn from the text
- Analyze the connections among and distinctions between individuals, events, or ideas in a text
- Describe how characters respond or change as a plot progresses
- Compare and contrast how the same event, person, or place is presented in texts of the same genre written by different authors
- Synthesize information from several locations in two or more texts on the same topic to develop new ideas about that topic

**Main Ideas and Themes**

- Determine the main ideas or themes of texts and explain how key details support them
- Summarize information developed across a text, preserving the sequence of development in the summary
- Summarize stories and other narratives with simple, external conflicts and plots primarily in chronological order or with simple, heavily signaled flashbacks
- Compare and contrast the main ideas or themes of two or more texts

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases as they are used in a text, including figurative, connotative, and technical meanings
- Determine the meaning of figurative language and literary devices, such as symbolism or irony, from context
- Analyze how language evokes a sense of time and place, drawing on one or more examples

**Text Structure**

- Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to the development of the ideas
- Analyze how narrative structure and style affect meaning
- Identify how two or more texts provide contrasting information and explain how the new information influences each text

**Purpose and Point of View**

- Determine an author's purpose and explain how structure and content support that purpose
- Determine an author's point of view and how the author distinguishes his or her position from that of others
- Identify unstated assumptions that influence the ideas or information presented in the text
- Analyze how an author develops and contrasts different characters' or narrators' points of view in a text
- Analyze how two or more authors develop different interpretations of facts or evidence in order to advance different points of view or perspectives on the same topic

**Arguments**

- Identify and evaluate the claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not
- Analyze how fact and opinion function in texts to create bias or affect tone
- Compare and contrast two or more texts that present conflicting arguments

# Grade 8

By the end of eighth grade, students have read a variety of narrative and informational texts across the ACT *straightforward*, *somewhat challenging*, and *more challenging* text complexity levels. Students have read all genres of literary and informational texts. Across the curriculum, informational texts are emphasized as essential to building content knowledge and understanding. The texts include print and digital sources that vary considerably in length and format. Texts have a wide range of often multifaceted structures, are written for several different purposes, and include academic and domain-specific language and literary devices that often express abstract ideas. Students process text with increasing fluency, accuracy, and independence. They monitor their understanding and use appropriate strategies to accomplish a wide range of learning tasks. They understand and think critically about information and ideas, and they synthesize information across different texts on a given topic, considering multiple perspectives as well as their own. In order to develop their understanding, students draw connections between ideas in the texts and their own experiences. They show a growing awareness of texts' purposes and understand how these relate to texts' structures, draw increasingly automatic and accurate local and global inferences, determine the meaning of uncommon words using multiple approaches and a variety of reference materials, and confidently read a variety of sentence structures.

# Text Complexity Levels

### Straightforward

Straightforward texts have a clear purpose and organization with explicit transitions and include varied sentence structures. Vocabulary may include some general academic or uncommon words and phrases. These texts may require inferences and contain some abstract concepts and diverse perspectives. Visual elements, including pictures and graphics, may have higher informational content and support understanding of the text.

Informational texts exhibit features of the field of study (e.g., science), including some domain-specific language, and assume broad content knowledge.

Literary texts have a single narrator and conflicts that are straightforward and usually external. Plots may deviate from chronological order with simple, heavily signaled flashbacks or flash-forwards. These texts may include some nonliteral language and simple literary devices. Major and minor characters may show some depth, and the text offers basic insights into characters, people, situations, and events (e.g., simple motives).

### Somewhat Challenging

Somewhat challenging texts have a clear purpose and organization with varied sentence structures and transitions. Vocabulary may include some general academic or uncommon words and phrases. These texts require inferences and contain abstract concepts as well as experiences and perspectives that may differ from those of the reader.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume everyday knowledge and content knowledge appropriate to the grade. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and nonlinear plots with clearly signaled shifts in point of view or time. Characters are dynamic and experience uncomplicated internal or external conflicts. These texts may include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter may be challenging, offering insights into people, situations, and events.

### More Challenging

More challenging texts may have a multifaceted purpose and organization with varied and often complicated sentence structures. Vocabulary includes general academic and uncommon words and phrases. These texts may depict several abstract concepts and require students to interpret and evaluate.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume discipline-specific content knowledge. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and well-rounded characters who may experience subtle internal or external conflicts. Plots may be nonlinear or parallel and may lack resolution. These texts include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter are challenging, offering deep insights into people, situations, and events.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in grade 8 can do the following:**

**Close Reading**

- Use textual evidence to analyze what the text says explicitly and to support inferences drawn from the text
- Analyze the connections among and distinctions between individuals, events, or ideas in a text
- Analyze how particular lines of dialogue or incidents in a story cause other events, reveal traits of a character, or influence a decision
- Compare and contrast how the same event, person, or place is presented in texts of the same genre written by different authors
- Analyze how two or more texts provide contrasting information and identify how the new information influences each text

**Main Ideas and Themes**

- Determine the main ideas or themes of texts that may depict several abstract concepts or explore insights into people, situations, or events
- Summarize increasingly dense and multifaceted text, avoiding minor details, extraneous background information, and personal reflection or bias
- Summarize stories and other narratives which may have nonlinear plots and characters with subtle internal or external conflicts
- Compare the themes and concepts of two texts of historical or literary significance

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases as they are used in a text, including figurative, connotative, and technical meanings
- Determine the meaning of figurative language and literary devices from context and discuss different interpretations
- Analyze how literal and figurative language shape the meaning and tone of the text, drawing on several examples

**Text Structure**

- Analyze the structure of a specific paragraph in a text, including the role of particular sentences in developing and clarifying a key concept
- Analyze how narrative structure and style affect meaning
- Compare and contrast the structure of two texts and analyze how the differing structure of each text contributes to its meaning and style

**Purpose and Point of View**

- Determine an author's purpose in a text that may have multifaceted purposes or numerous abstract concepts
- Determine an author's point of view and how the author distinguishes his or her position from that of others when the differences are subtle
- Analyze how an author's use of language and persuasive devices support his or her purpose
- Analyze how differences in the points of view of the characters create effects such as suspense or humor
- Analyze how two or more authors develop different interpretations of facts or evidence in order to convey different perspectives on the same topic

**Arguments**

- Identify and evaluate the specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not
- Evaluate whether an author's claims are consistent and logical
- Compare and contrast two or more texts that present conflicting arguments

# Early High School (Grades 9 and 10)

By the end of tenth grade, students have read a variety of narrative and informational texts across the ACT *somewhat challenging*, *more challenging*, and *complex* text complexity levels. Students have read all genres of literary and informational texts. Across the curriculum, informational texts is emphasized as essential to building content knowledge and understanding. The texts include print and digital sources that vary considerably in length and format. Texts have a wide range of multifaceted structures, are written for several different purposes, and include academic and domain-specific language and literary devices that often express abstract ideas. Students process complex texts with fluency, accuracy, and independence. They monitor their understanding and use appropriate strategies to accomplish more sophisticated learning tasks. They understand and think critically about information and abstract ideas, make and adjust inferences and interpretations, and synthesize information that is increasing varied and unfamiliar across different texts on a given topic, considering multiple perspectives as well as their own. In order to extend their understanding, students draw connections between ideas in the texts and their own experiences. They can easily show awareness of text purposes (including those that are unique to a discipline), understand how these relate to text structures, and increasingly relate texts' structures and authors' techniques to ideas in texts. They also show growing awareness that texts can support multiple interpretations and understandings. Students automatically draw accurate local and global inferences, determine the meaning of uncommon words using multiple approaches and a variety of reference materials, and confidently read complex sentence structures.

# Text Complexity Levels

### Somewhat Challenging

Somewhat challenging texts have a clear purpose and organization with varied sentence structures and transitions. Vocabulary may include some general academic or uncommon words and phrases. These texts require inferences and contain abstract concepts as well as experiences and perspectives that may differ from those of the reader.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume everyday knowledge and content knowledge appropriate to the grade. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and nonlinear plots, with clearly signaled shifts in point of view or time. Characters are dynamic and experience uncomplicated internal or external conflicts. These texts may include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter may be challenging, offering insights into people, situations, and events.

### More Challenging

More challenging texts may have a multifaceted purpose and organization with varied and often complicated sentence structures. Vocabulary includes general academic and uncommon words and phrases. These texts may depict several abstract concepts and require students to interpret and evaluate.

Informational texts exhibit features of the general discipline (e.g., natural science), including domain-specific language, and assume discipline-specific content knowledge. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple narrators and well-rounded characters who may experience subtle internal or external conflicts. Plots may be nonlinear or parallel and may lack resolution. These texts include nonliteral language and literary devices such as symbolism or irony. Themes and subject matter are challenging, offering deep insights into people, situations, and events.

### Complex

Complex texts may have complex structure and purpose that might not be evident upon first reading. Vocabulary and syntax are sophisticated and may include words or structures uncommon in contemporary texts. Numerous abstract concepts require students to interpret and evaluate. In these texts, students may encounter experiences, values, and perspectives different from their own.

Informational texts have high concept density and consistently use domain-specific and general academic vocabulary. Visual elements, including pictures and graphics, may have high informational content and support understanding of the text.

Literary texts may have multiple or unreliable narrators and well-rounded characters with complex conflicts that lack easy resolution. These texts may use unconventional language structures (e.g., stream of consciousness) and challenging literary devices (e.g., extended metaphors, satire, parody). Themes and subject matter may be mature, offering profound insights or philosophical reflection.

**Building on proficiencies developed in earlier grades in increasingly complex texts, students in early high school can do the following:**

**Close Reading**

- Use strong and thorough textual evidence to analyze what the text says explicitly and support inferences drawn from the text
- Analyze the interactions between individuals, events, and ideas in a text
- Analyze how complex characters develop over the course of a text, interact with other characters, and advance the plot or develop the theme
- Compare and contrast two or more texts from the same time period
- Analyze how two or more texts provide contrasting information and evaluate why the new information is important for answering a question or making an interpretation

**Main Ideas and Themes**

- Determine the main ideas or themes of texts that are dense and have abstract or philosophical ideas
- Summarize text with abstract content, unconventional structure, and purposes that are not immediately evident (may require adding structure or reorganizing content)
- Summarize stories and other narratives which may have unreliable narrators and characters with complex conflicts that lack easy resolution
- Analyze the themes and concepts of two texts of historical or literary significance, using brief summaries to help the comparison and analysis

**Word Meanings**

- Determine the meaning of general academic and domain-specific words and phrases as they are used in a text, including figurative, connotative, and technical meanings
- Determine the meaning of more complex figurative language and literary devices, such as extended metaphor or satire, from context and evaluate different interpretations
- Analyze the effect of word choice on meaning and tone over an entire text

**Text Structure**

- Analyze how an author's ideas or claims are developed and refined by choices about the structure of sentences, paragraphs, or the text as a whole
- Analyze how an author's choices about the order of events create such effects as mystery, tension, or surprise
- Compare and contrast the structure of two texts and analyze how the differing structure of each text contributes to its meaning and style

**Purpose and Point of View**

- Determine an author's purpose that may not be immediately evident in a text
- Analyze how the author acknowledges and responds to conflicting evidence and perspectives
- Analyze how an author's use of language and persuasive devices supports his or her purpose
- Determine a narrator's point of view and analyze how an author's use of language advances that point of view or creates specific effects, such as reliability
- Analyze how two or more authors develop different interpretations of—or omit—facts or evidence in order to convey different perspectives on the same topic

**Arguments**

- Evaluate the specific claims in a text, assessing whether the evidence is relevant and sufficient
- Evaluate whether an author's claims are consistent and logical
- Evaluate two or more arguments on a specific topic to determine which argument is strongest or most persuasive

Appendix C

# ACT Aspire Grade Level Targets for Mathematics

## Grade 3

Students entering grade 3 recognize area and ways to have equal area by partitioning shapes into a small number of equal-size pieces, including dividing rectangles into arrays of squares. In grade 3, the concept of area measurement develops in terms of covering a variety of 2-dimensional figures with copies of the same reference shape, and in terms of the concept of standard comparison to 1 × 1 "unit" squares.

Entering students bring an understanding of addition and subtraction, as well as counting by 2s, 5s, 10s, and 100s, and use that to understand multiplication in terms of combining equal-size groups and to understand division as forming equal-size groups for sharing. Arrays and area provide models for multiplication and division that will carry through into later grades. Students see connections between multiplication and division in terms of all these representations (combining equal-size groups, fair sharing, arrays, and area) as well as through solving multiplication and division problems within 100. Connections between area and multiplication also lead to understanding that the measure of a rectangular area can be computed by multiplying length and width when the distances are whole numbers, which will generalize in later grades and will be used to develop area formulas.

Prior to grade 3, students have seen very simple unit fractions that describe equal-sharing of a "whole." Grade 3 further develops understanding of unit fractions. Other fractions are then combinations of unit fractions, and students see special cases of equivalent fractions. Students compare fractions by using area models and length models, including the number line, and by making observations based on equal denominators or equal numerators, always keeping in mind the relationship to the same "whole." This will be the basis for fuller understanding of equivalent fractions in grade 4 and for future ways to compute with rational numbers.

Students deepen their place-value understanding, using strategies and algorithms to add and subtract within 1,000. Students use place-value understanding to multiply 1-digit whole numbers by small multiples of 10, preparing for fluent multidigit multiplication in grade 4. Grade 3 students fluently multiply and divide within 100 using strategies based on place-value, the relationship between multiplication and division, and other properties of operations. They solve problems using all four operations.

Students in grade 3 also compare and classify 2-dimensional shapes by their properties (for example, number of sides and angles) and develop property-based definitions of shapes.

Grade 3 students are building and using structure in place-value, the number line, properties of operations, equations, computation, elements of problems and problem solving, geometric shapes and properties, fractions and fraction models, and more. Using structure helps students make sense of problems. Students draw logical conclusions and justify with a few statements presented in a coherent sequence. The use of models deepens in grade 3, with multiplication and fraction understanding developing through the use of lasting models. Mathematical discussion and measuring with a ruler both develop precision.

# Number and Quantity

## Whole Numbers

Understand why rounding numbers to a specific place value is useful and apply the procedure to round whole numbers up to 1000

## Fraction Concepts

Investigate and describe the equipartitioning of whole number intervals on a number line for denominators 2, 3, 4, 6, & 8

Investigate and describe the equipartitioning of whole number intervals on a number line

Express whole numbers as fractions

Generate simple equivalent fractions by using models and splitting techniques

Investigate and generate equivalent fractions

Compare two fractions with the same numerator or same denominators, for denominators 2, 3, 4, 6, & 8

# Operations, Algebra, and Functions

## Addition and Subtraction

Represent addition and subtraction problems with models, expressions, and equations

Represent comparison problems with models, expressions, and equations

Add and subtract whole numbers within 1000 with fluency

### Multiplication and Division

Use arrays and equipartitioning to explore multiplication and division relationships, and represent multiplication and division situations with expressions and equations

Recognize multiplicative comparison situations

Solve simple multiplication and division problems by applying properties of multiplication and recalling basic facts

Multiply one digit by two digit factors with products less than 100 and divide using known multiplication facts

### Multistep Problems

Set up and solve multistep word problems about time or money using addition and subtraction

### Elapsed Time

Calculate elapsed time with whole hours and convert between whole hours and minutes

Calculate elapsed time with 30 minutes at the beginning or end of an interval and convert between hours and whole days

Calculate elapsed time with 15-minute intervals as well as find the starting time of an elapsed time problem and convert between days and whole years

Calculate elapsed time with 1-minute intervals and intervals less than one hour long

### Expressions

Represent numbers in real-world or mathematical problem with variables

## Geometry and Measurement

### Plane Figures

Make informal models of 2-D figures

Estimate and measure lengths using tools and standard length units (e.g., inches, centimeters, etc.)

Investigate perimeter and solve problems about rectangular perimeter

Understand and apply formulas to solve problems about perimeter of rectilinear figures

Understand and apply formulas to solve problems about perimeter of regular polygons and circles

Indirectly compare area and rearrange parts of a 2-D figure to directly compare area

Recognize area as an attribute of 2-D figures and measure area by laying appropriate units

Use rectangular arrays to model and solve 1-digit factor multiplication problems

### 3-Dimensional Figures

Recognize filling volume as an attribute of 3-D figures and measure it with fluid units

Add and subtract to solve problems about filling volume

Understand and apply principles of transitivity and composition to compare filling volume

Measure and interpret measures of mass in whole number kilograms and grams

Estimate, solve problems about, and measure mass, and interpret mass measures in kilograms and grams

Estimate, solve problems about, and measure weight, and interpret weight measures in pounds and ounces

## Statistics and Probability

### Descriptive Statistics

Create and understand picture charts, line plots, tally charts, bar graphs, circle graphs, and data tables, and use them to solve problems

# Grade 4

Fluency in whole-number computation with the four operations comes with practice, for example, solving problems and learning to carry out computation without disrupting the flow of problem solving. Fluency includes flexibility, using properties of operations (for example, the distributive property) to obtain results and not always falling back on a standard algorithm. Students in grade 4 make multidigit calculations using place-value reasoning, for whole numbers and for decimals to hundredths. Recording calculations using mathematical notation is a way for students to display their thinking so that they can review their work and share it with others.

In grade 4, students build the structure of a multiplicative relationship through multiplicative comparison, working with factors and multiples, and generating patterns. In later grades, this develops into the concept of a function. Multiplicative relationships have modeling applications appropriate for grade 4 students, and they are also a way to understand converting a measurement in a larger unit (for example, hours) to a measurement in a smaller unit (for example, minutes) within a measurement system.

Students enter grade 4 recognizing some equivalent fractions, and in grade 4 they develop this concept and use it to compare fractions. In later grades, the concept will be used to add and subtract fractions with different denominators. Students in grade 4 add and subtract fractions with like denominators, extending to include mixed numbers and decimals in tenths or in hundredths. Fractions are built from unit fractions through a multiplicative relationship, and this relationship provides a way to understand multiplying a fraction and a whole number.

Fractions provide a tool for increased precision when measuring or discussing quantities. Data displays from prior grades are extended in grade 4 to include appropriate fractions. On the number line, addition and subtraction of fractions with like denominators parallels addition and subtraction of whole numbers.

In grade 4, the concept of the size of an angle is quantified, and students see that angle measure has some of the same properties as length measure. Students categorize geometric figures using angle measure and understand parallel lines and lines of symmetry.

# Number and Quantity

## Whole Numbers

Read and write the numerals, number names, and expanded forms for numbers 0–1000

Read and write the numerals, number names, and expanded forms for numbers 0–1,000,000

Read and write the expanded, exponential forms for numbers 0–1,000,000

Read and write the expanded, exponential forms for a number

Understand that a digit in one place is worth ten times a digit to its left and 1/10 times a digit to its right

Write comparison sentences for multidigit numbers

Understand why rounding numbers to a specific place value is useful and apply the procedure to round whole numbers up to 1000

Provide rationale for rounding to a specific place value and round whole numbers up to 1,000,000

Round whole numbers beyond 1,000,000

## Fraction Concepts

Investigate and describe the equipartitioning of whole number intervals on a number line for denominators 2, 3, 4, 6, 8, 10, 12, & 100

Investigate and describe the equipartitioning of whole number intervals on a number line

Rewrite fractions with denominators of 10 or 100

Investigate and generate equivalent fractions

Compare and order fractions with different numerators and denominators, for denominators 2, 3, 4, 5, 6, 8, 10, 12, 100

Order fractions

# Operations, Algebra, and Functions

## Addition and Subtraction

Add and subtract whole numbers greater than 1000 with fluency

Model the combining of fractional parts with the same denominator

Calculate the sums and differences of fractions and mixed numbers with like denominators

## Multiplication and Division

Use arrays and equipartitioning to explore multiplication and division relationships, and represent multiplication and division situations with expressions and equations

Recognize multiplicative comparison situations

Solve simple multiplication and division problems by applying properties of multiplication and recalling basic facts

Determine and distinguish between multiples of numbers up to 12 and factors of numbers up to 100

Multiply one digit by two digit factors with products less than 100 and divide using known multiplication facts

Divide whole numbers by their factors with fluency

Divide whole numbers by any divisor with fluency

Model and solve unit fraction or fraction and whole number multiplication problems

Estimate and solve fraction multiplication problems

## Multistep Problems

Set up and solve two-step whole number problems using the four operations

Set up and solve multistep whole number problems using the four operations

Simplify expressions involving fractions and the four operations

Set up and solve multistep word problems about time or money using addition and subtraction

Set up and solve multistep word problems about time or money using the four operations

## Elapsed Time

Calculate elapsed time with whole hours and convert between whole hours and minutes

Calculate elapsed time with 30 minutes at the beginning or end of an interval and convert between hours and whole days

Calculate elapsed time with 15-minute intervals as well as find the starting time of an elapsed time problem and convert between days and whole years

Calculate elapsed time with 1-minute intervals and intervals less than one hour long

Calculate elapsed time that spans 12:00 and solve word problems about time intervals

## Expressions

Represent numbers in real-world or mathematical problems with variables

## Function Concepts

Generate and identify rules of patterns

## Sequences and Series

Model arithmetic and geometric sequences from descriptions or lists

Find missing values or sums of arithmetic or geometric sequences

# Geometry and Measurement

## Plane Figures

Classify quadrilaterals

Make informal models of 2-D figures

Classify triangles

Lines of symmetry

Build models of two-dimensional figures

Identify, draw, and label points, lines, line segments, and rays on a plane

Apply definitions of special angle types in order to classify angles as right, acute, obtuse, straight, and reflex

Recognize and draw right, acute, obtuse, straight, and reflex angles

Compare 2-line angles and model angle measure as degree of rotation

Identify and use the characteristics of 1-line angles and parts of 2-line angles

Identify and use the characteristics of 0-line angles

Classify angles as acute, obtuse, right, straight, or reflex based on angle measure in degrees and/or visual inspection

Measure angles with a protractor and by reasoning about the additive nature of angle measure

Identify points, lines, and angles within a circle

Compare, add, and subtract lengths to solve problems about length

Investigate perimeter and solve problems about rectangular perimeter

Understand and apply formulas to solve problems about perimeter of rectilinear figures

Understand and apply formulas to solve problems about perimeter of regular polygons and circles

Use rectangular arrays to model and solve 1-digit factor multiplication problems

Solve problems about rectangular area using the formula $A = l \times w$ with whole number side lengths

### 3-Dimensional Figures

Estimate, solve problems about, and measure weight, and interpret weight measures in pounds and ounces

### Units of Measure

Know and use unit conversions to convert larger units to smaller units within a system

Know and use unit conversions to convert units within a system

## Statistics and Probability

### Descriptive Statistics

Create and understand picture charts, line plots, tally charts, bar graphs, circle graphs, and data tables, and use them to solve problems

# Grade 5

Building on prior work with fractions that have the same denominator, students in grade 5 address addition and subtraction of fractions with different denominators by making equivalent computations, justified, for example, through fraction models. Students then extend to mixed numbers and decimals. Students can also estimate with fractions: for example, using the number line.

Rectangular area measure and fraction multiplication develop together, where students see how a “whole” represented by a square is partitioned and shaded to represent fraction multiplication. Then students measure the shaded area by covering it with rectangles of known area, confirming that the area of a rectangle with fraction-length sides can be calculated as length times width. This area model then depicts multiplication of fractions in terms of numerators and denominators, resulting in an algorithm for computation. Many students should anticipate these results because it is expressing regularity about fraction reasoning that became a focus starting in grade 3.

Division as forming equal-size groups for sharing applies to fractions as well as to whole numbers. Using fraction models, students can partition a whole number into parts the size of a given unit fraction or can partition a unit fraction into a given whole number of parts. The relationship between multiplication and division shows that a fraction represents division, and also that dividing by a whole number is equivalent to multiplying by a unit fraction. It’s important for students to understand this at a deeper level than an algorithmic rule.

Multistep computations may be recorded in grade 5 using the conventions of order-of-operations, now with the use of grouping symbols such as parentheses. Students continue to use letters or symbols to replace an unknown quantity, now in more-complex equations and inequalities. Students can perform multidigit computations using place-value strategies or models, and can explain why the computation is correct. Place-value patterns extend across the decimal point and can be used to justify algorithms for computing with decimals. Place-value also is the basis for rounding to a given decimal place. Problem solving utilizes abstraction to represent the situation followed by a fluent computation and then by interpreting the computed number as a possible answer.

The coordinate plane will be used to model many concepts in future grades, including maps and functions. In grade 5, students locate points in the first quadrant and interpret coordinate values in a problem context.

Grade 5 develops volume measure in terms of packing with unit cubes, in the same fashion as earlier grades developed area measure in terms of covering with unit squares. The volume of a right rectangular prism with whole-number sides relates to multiplication of whole numbers. Volume is additive in the same way that area and length are additive. This illustrates repeated reasoning across different geometric dimensions.

Students have categorized geometric objects in prior grades, and in grade 5 students begin to look at the structure of categories by thinking about relationships between categories and subcategories. Students see that properties can be inherited: a property of all members of a category is a property of all members of a subcategory. Making viable arguments about categories in terms of all or some or no elements builds student reasoning skills.

# Number and Quantity

## Whole Numbers

Understand that a digit in one place is worth ten times a digit to its left and 1/10 times a digit to its right

Understand the effects of multiplying or dividing a number by 10 and use exponents to denote powers of 10

## Decimals

Represent decimals to tenths with visual models, fractions, and decimal notation

Represent decimals to hundredths with visual models, fractions, and decimal notation

Represent decimals to thousandths with visual models, fractions, and decimal notation

Represent equivalent notations for decimals to hundredths

Represent equivalent notations for decimals

Multiply and divide numbers by powers of ten

Read and write decimals to the tenths in standard notation, number names, and expanded form

Read and write decimals to the hundredths in standard notation, number names, and expanded form

Read and write decimals to the thousandths in standard notation, number names, and expanded form

Read, write, and recompose decimals written in standard notation, number names, expanded form, and exponential form

Compare, order, and locate on a number line decimals to the tenths

Compare, order, and locate on a number line decimals to the hundredths

Compare, order, and locate on a number line decimals to the thousandths

Round decimal numbers with digits up to the thousandths place

Round decimal numbers

# Operations, Algebra, and Functions

## Addition and Subtraction

Understand the relationship between addition and number position on the number line

Understand the relationship between subtraction and number position on the number line

Estimate and calculate the sums and differences of fractions and mixed numbers with unlike denominators

Add and subtract decimals to the hundredths and whole numbers

Add and subtract multidigit decimals with fluency

## Multiplication and Division

Use arrays and equipartitioning to explore multiplication and division relationships, and represent multiplication and division situations with expressions and equations

Recognize multiplicative comparison situations

Solve simple multiplication and division problems by applying properties of multiplication and recalling basic facts

Multiply multidigit whole numbers with fluency

Divide whole numbers by their factors with fluency

Divide whole numbers by any divisor with fluency

Model and solve unit fraction or fraction and whole number multiplication problems

Estimate and solve fraction multiplication problems

Model and solve unit fraction or fraction and whole number division problems

Estimate and solve fraction division problems

Multiply whole numbers and decimals to the hundredths

Divide decimals to the hundredths by whole numbers

Multiply decimals to the hundredths

Divide whole numbers and decimals to the hundredths by decimals

Multiply and divide multidigit decimals with fluency

## Multistep Problems

Set up and solve two-step whole number problems using the four operations

Set up and solve multistep whole number problems using the four operations

Set up and solve multistep fraction word problems using the four operations

Simplify expressions involving fractions and the four operations

Set up and solve multistep word problems about time or money using addition and subtraction

Set up and solve multistep word problems about time or money using the four operations

## Operations with Money

Calculate change owed and round monetary values

## Expressions

Represent numbers in real-world or mathematical problem with variables

Generate equivalent expressions using arithmetic properties

## Function Concepts

Generate and identify rules of patterns

## Sequences and Series

Model arithmetic and geometric sequences from descriptions or lists

Find missing values or sums of arithmetic or geometric sequences

# Geometry and Measurement

## Plane Figures

Classify quadrilaterals

Make informal models of 2-D figures

Classify triangles

Build models of two-dimensional figures

Graph points on the coordinate plane

Solve problems represented on the coordinate plane

Solve area problems using non-square units and fractional units

### 3-Dimensional Figures

Investigate and directly compare packing volume of rectangular prisms

Understand and apply principles of transitivity and composition to compare packing volume

Recognize packing volume as an attribute of 3-D figures and measure it with cubic units

Investigate and use formulas to solve problems about packing volume of rectangular prisms with whole number side lengths

Use formulas to solve problems about packing volume of 3-D figures with rectangular, triangular, and circular bases and spheres

### Units of Measure

Know and use unit conversions to convert larger units to smaller units within a system

Know and use unit conversions to convert units within a system

## Statistics and Probability

### Descriptive Statistics

Create and understand picture charts, line plots, tally charts, bar graphs, circle graphs, and data tables, and use them to solve problems

# Grade 6

Quantities in the world, for example, time and distance traveled, vary. When an equation relates one quantity to the other, graphs and tables also represent the relationship. Students in grade 6 can use these representations to make conclusions and mathematical arguments.

Grade 6 has a focus on multiplicative relationships, also called proportional relationships, and introduces the concept of a ratio that represents this type of relationship. Many real-world situations can be modeled with ratios, and later grades connect proportional relationships to certain linear equations.

By developing division of fractions in grade 6, students complete the development of the 4 operations with fractions that started in grade 3. This step builds upon understanding of multiplication and division from prior grades and fits neatly into the framework of a proportional relationship. Students understand fraction models for division and see connections that lead to expressing regularity in terms of a general algorithm for dividing fractions.

Negative numbers can be useful for modeling situations where there is an anchor point (for example, 0° on a temperature scale) and where values have meaning relative to that anchor point (for example, above or below 0° and by how much). Giving meaning to negative numbers and to absolute value as distance from the zero point provides an avenue for students to create viable arguments. Students will learn about computation with negative numbers in grade 7 and explore the rational numbers as a system. In grade 6, the number line is extended to have a place for all rational numbers, and the coordinate plane, for all pairs. Students represent polygons across all quadrants of the coordinate plane and find the length of horizontal and vertical line segments.

Each part of a multistep computation has meaning, and this meaning is also seen in the structure of expressions that record the computation. When a letter stands for a quantity in a computation, the expression can take on different values depending on what value the quantity might have. Students in grade 6 record computations with exponents. They understand the conventions (order of operations) that make expressions well defined. They understand that it is not efficient to always do operations in the same order as the order of operations specifies, but the computation must be done in an equivalent way so that the result is the same. This principle provides opportunity for strategic decisions when making computations. Properties of operations can lead to equivalent ways to do computations. Some properties are already in use, such as the distributive property, and some properties will be developed in future grades. Calculators also provide opportunity for strategic decisions when making computations.

In prior grades, students have created equations and inequalities by replacing a number with a letter or symbol. Grade 6 students begin to turn this into a general tool for solving problems, a pursuit that will keep building through future grades and that will be a key to success in future grades. Equations and inequalities express relationships that can sometimes be deduced from problem contexts with an unknown number. Finding the unknown number is one step in solving the problem. Because the unknown number must make the equation or inequality true, one can check numbers by substituting into the equation and completing the computation.

Using the relationship between addition and subtraction, and between multiplication and division, students solve 1-step equations. Students write restrictions such as $x > c$ and recognize infinitely many solutions, which can be represented by a ray (in this case, without endpoint) on the number line.

Students in grade 6 also build their justification skills by developing methods and formulas for finding the areas of triangles, special quadrilaterals, and polygons by composing from or decomposing into other shapes. The process starts with a rectangle. Each new method or formula can be derived from a rectangle or from another figure (for example, a triangle) whose derivation traces back to a rectangle.

In prior grades, students developed a formula for the volume of a right rectangular prism with whole-number side lengths, and in grade 6 they extend this result to fraction-length sides. They find nets made from rectangles and triangles that correspond to 3-dimensional figures and use these nets to find surface area.

A question is a statistical question when you care about a whole set of answers to the question, not just a single answer. How many books has a classmate read this month? One classmate may have read 12 books, and another may have read 4 books, and there may be many other answers. The set of answers has a distribution that has a pattern. Dot plots, histograms, and box plots summarize the answers to a statistical question, as do measures of center and spread, and descriptions of overall shape. The context of the data is important to making conclusions. Context includes the number of observations and the nature of what is being recorded. Students in grade 6 summarize data and can justify their choice of measures of center (mean, median, or mode) and variability (range, interquartile range, or mean absolute deviation) in terms of the shape of the distribution and the context.

# Number and Quantity

## Signed Numbers

Understand and order integers, both positive and negative

Understand and evaluate inequalities involving signed integers

Understand and order absolute values of integers

Understand rational numbers, both positive and negative

Order integers and rational numbers

Understand and order absolute values of rational numbers

## Real and Complex Numbers

Understand and use positive integer exponents

# Operations, Algebra, and Functions

## Addition and Subtraction

Understand the relationship between addition and number position on the number line

Understand the relationship between subtraction and number position on the number line

Represent addition and subtraction problems with models, expressions, and equations

Represent comparison problems with models, expressions, and equations

Add and subtract decimals to the hundredths and whole numbers

Add and subtract multidigit decimals with fluency

## Multiplication and Division

Solve simple multiplication and division problems by applying properties of multiplication and recalling basic facts

Determine and distinguish between multiples of numbers up to 12 and factors of numbers up to 100

Determine and distinguish between common factors and multiples of numbers up to 100

## Multistep Problems

Set up and solve two-step whole number problems using the four operations

Set up and solve multistep whole number problems using the four operations

Set up and solve multistep fraction word problems using the four operations

Simplify expressions involving fractions and the four operations

Set up and solve multistep problems with decimals to the hundredths using the four operations

Set up and solve multistep problems with multidigit decimals using the four operations

## Ratio and Proportion

Understand ratio concepts

Solve ratio and rate problems

Interpret and represent ratios

Understand proportion concepts

Solve proportion problems

Solve problems about percent

## Expressions

Recognize expressions and their parts

Evaluate expressions at specific values of variables

Represent numbers in real-world or mathematical problems with variables

Generate equivalent expressions using arithmetic properties

Simplify expressions with whole number coefficients and exponents, combining like terms

Simplify expressions with rational coefficients and exponents

## Function Concepts

Translate between different representations of linear relationships: graphs, equations, sets of ordered pairs, verbal descriptions, and tables

Find the rate of change and initial values from a table, graph, or verbal description

## Equations and Inequalities

Solve one-step equations and inequalities and graph solutions

## Operations with Real and Complex Numbers

Simplify numbers or expressions involving exponents, roots, and scientific notation

Add, subtract, multiply, and divide expressions involving exponents, roots, and scientific notation

# Geometry and Measurement

## Plane Figures

Make informal models of 2-D figures

Classify triangles

Build models of two-dimensional figures

Graph points on the coordinate plane

Solve problems represented on the coordinate plane

Solve area problems using non-square units and fractional units

Apply formulas and reason about shapes to solve problems about area of quadrilaterals, triangles, and complex polygons

## 3-Dimensional Figures

Recognize attributes of and name 3-D figures

Investigate surface area as an attribute of 3-D figures and solve problems about surface area by reasoning about a figure's base(s) and faces

Solve problems about surface area of figures with rectangular and triangular bases by using a formula

Use formulas to solve problems about packing volume of rectangular prisms with fractional number side lengths

## Units of Measure

Know and use unit conversions to convert units between two systems

# Statistics and Probability

## Descriptive Statistics

Create and understand picture charts, line plots, tally charts, bar graphs, circle graphs, and data tables, and use them to solve problems

Create and understand dot plots, histograms, box-and-whisker plots, and stem-and-leaf plots, and use them to solve problems

Find measures of the center of a distribution

Find measures of the spread of a distribution

Describe the shape of a distribution and use it to analyze a dataset

Interpret center, spread, and shape of a distribution in context, including the effect of outliers

# Grade 7

The study of ratios in grade 6 generalizes to rates (with an emphasis on unit rates) in grade 7. Students learn to test for and recognize proportional relationships between quantities, and they express these relationships with an equation, with a graph, and with a table of values. Using these tools, students in grade 7 can solve multistep ratio and percent problems. As students repeat this type of reasoning, they will become more comfortable analyzing problems, abstracting, solving an equation, and recontextualizing—creating a viable argument as needed. Strategic use of calculators can make problem solving more efficient and allow exploration.

Coming into grade 7, students have the basic tools needed for computing with rational numbers, but viewing the rational numbers as a system adds power and flexibility for computation. Grade 7 develops properties of the system, such as viewing subtraction in terms of adding the opposite (the additive inverse), and multiplication in terms of remaining consistent with the distributive property. Any two rational numbers can be added, subtracted, multiplied, or divided, and the result is always a rational number (except when dividing by zero). Students in grade 7 can solve multistep problems, reasoning with rational numbers and the 4 operations.

Computations with rational numbers develops in parallel with making meaning of and manipulating algebraic expressions—because algebraic expressions represent computations with rational numbers. Students solve problems, use variables, and construct simple equations and inequalities. Students reason about quantities, compare algebraic and numeric solutions, and show results graphically.

Scale drawings are proportional relationships, and working with scale drawings develops a concrete understanding of proportion and of scaling, topics that continue into future grades. Students in grade 7 also continue to look at geometric properties and conditions and relations, with some focus on triangles to prepare for congruence in grade 8. Students envision and represent simple cross-sections. They learn about circles and can describe the connection between area and circumference.

Students entering grade 7 have been exposed to data distributions, and in grade 7 they will understand the value of using samples to make a prediction about a population. This kind of inference depends on having a representative sample, and students develop sampling distributions, with random sampling, as a way to judge representativeness and variability. Students also continue analyzing data distributions, now comparing 2 different data distributions and interpreting differences in the context of the data, which will be a starting point in high school.

These statistical comparisons are qualitative. To make them quantitative requires probability, and students in grade 7 develop a language for discussing chance events and an empirical understanding of probability. This connects to probability models and compound events. Organized lists and tree diagrams are tools for representing the sample space. Simulation models the probability of a compound event. Empirical thinking is the base for statistical reasoning, deeply rooted in the practice of modeling.

# Geometry and Measurement

## 3-Dimensional Figures

Investigate surface area as an attribute of 3-D figures and solve problems about surface area by reasoning about a figure's base(s) and faces

Solve problems about surface area of figures with circular bases by using a formula

Solve problems about surface area of figures with rectangular and triangular bases by using a formula

Understand and identify cross sections of three-dimensional figures

Use formulas to solve problems about packing volume of 3-D figures with rectangular, triangular, and circular bases and spheres

## Congruence, Similarity, and Transformations

Use scale drawings to determine actual lengths and distances

Use scales and scale drawings with measures of more than one dimension

## Plane Figures

Apply definitions of special angle pairs in order to classify and draw adjacent and vertical angles

Apply formulas and reason about shapes to solve problems about area of circles

Apply formulas and reason about shapes to solve problems about area of quadrilaterals, triangles, and complex polygons

Build models of two-dimensional figures

Classify triangles

Identify points, lines, and angles within a circle

Make informal models of 2-D figures

Recognize and create pairs of adjacent, supplementary, complementary, and vertical angles

Solve problems about angle pairs

Understand and apply formulas to solve problems about perimeter of regular polygons and circles

## Units of Measure

Know and use unit conversions to convert units between two systems

# Operations, Algebra, and Functions

## Addition and Subtraction

Add and subtract decimals to the hundredths and whole numbers

Add and subtract integers

Add and subtract multidigit decimals with fluency

Add and subtract rational numbers

Represent addition and subtraction problems with models, expressions, and equations

Represent comparison problems with models, expressions, and equations

Understand the relationship between addition and number position on the number line

Understand the relationship between subtraction and number position on the number line

## Equations and Inequalities

Solve and graph multistep and compound inequalities

Solve multistep equations and inequalities and graph solutions

Solve one-step equations and inequalities and graph solutions

Solve two-step equations and inequalities and graph solutions

## Expressions

Evaluate expressions at specific values of variables

Generate equivalent expressions using arithmetic properties

Represent numbers in real-world or mathematical problems with variables

Simplify expressions with rational coefficients and exponents

Simplify expressions with whole number coefficients and exponents, combining like terms

## Function Concepts

Find the rate of change and initial values from a table, graph, or verbal description

Translate between different representations of linear relationships: graphs, equations, sets of ordered pairs, verbal descriptions, and tables

## Multiplication and Division

Multiply and divide integers

Multiply and divide rational numbers

## Multistep Problems

Set up and solve multistep fraction word problems using the four operations

Set up and solve multistep integer problems following the order of the operations

Set up and solve multistep problems with decimals to the hundredths using the four operations

Set up and solve multistep problems with multidigit decimals using the four operations

Set up and solve multistep rational number problems following the order of the operations

Set up and solve multistep whole number problems using the four operations

Set up and solve multistep word problems about time or money using the four operations

Set up and solve two-step whole number problems using the four operations

Simplify expressions involving fractions and the four operations

## Ratio and Proportion

Interpret and represent ratios

Solve problems about percent

Solve proportion problems

Solve ratio and rate problems

Understand proportion concepts

Understand ratio concepts

# Statistics and Probability

## Descriptive Statistics

Find measures of the center of a distribution

Find measures of the spread of a distribution

Interpret center, spread, and shape of a distribution in context, including the effect of outliers

## Inferential Statistics

Identify and evaluate various sampling methods and types of statistical studies

Make inferences about and construct confidence intervals for parameters of a single population

Make inferences about and construct confidence intervals for parameters of two populations

Understand the relationship between population, sample, and sampling distribution

## Probability

Assign empirical probabilities to events

Calculate probabilities by constructing and analyzing sample spaces, and by using permutations and combinations

Make decisions based on probability

Understand random variables and their distributions

# Grade 8

Grade 8 students should be increasing their ability to abstract and work with abstractions, and at the same time should be attending to the difference between reality and the result of a mathematical model when they do mathematical modeling with functions or shapes or probability.

Functions are an abstraction of familiar relationships that students have been using in prior grades, relationships with consistent output from a given input. Students in grade 8 can connect different representations and use functions to model situations and solve problems. Proportional relationships define functions and connect to linear relationships, which form a family characterized by slope and *y*-intercept of their graphs. Students learn about linear relationships through graphs, tables, rate of change, and equations. Algebraic transformations (for example, to slope-intercept form) lead to properties of the family of linear equations in 2 variables, and these properties aid in solving problems and knowing about solutions. In grade 8, students learn to apply transformations strategically to solve linear equations in 1 variable, and to create a viable argument about the solution as needed. Properties and representations of linear equations also allow students to understand systems of linear equations, find simultaneous solutions, and recognize cases with different numbers of solutions.

Students entering grade 8 have built the rational number system, but there are numbers that are not rational. This is not generally a problem: tools for computing with rational numbers are also useful for these new numbers because rational numbers provide close approximations. Technology generally provides approximations, and students must understand the nature of these approximations in order to use the technology appropriately and strategically, an application of attending to precision.

Some of these new numbers arise in the context of radicals. In grade 8, students work with radicals and integer exponents, developing properties. The properties are determined by properties of addition, subtraction, multiplication, and division.

Geometric transformations are akin to functions. Rotations, reflections, and translations are a good starting point for study, allowing students to explore, reason, and express regularity. The idea of congruence is tied to these three transformations. Adding dilations ties to geometric similarity, with an important application to showing that slope of a line is well defined. Using properties of these transformations leads to regularity around, for example, angles created by parallel lines and a transversal. Grade 8 students make arguments to justify some of these relations as theorems. The Pythagorean theorem is within the grasp of grade 8 students, and they use the theorem to solve problems that involve right triangles or, equivalently, distance in the coordinate plane.

Building on an understanding of area and circumference from prior grades, students in grade 8 extend to volume of cones, cylinders, and spheres.

In grade 8, the focus on statistical patterns moves to looking at association between 2 quantities, something represented by scatter plots for quantitative variables and by 2-way tables for categorical variables. If a scatter plot suggests linear association, students can create a linear model, informally judge fit, interpret slope and *y*-intercept, and find other points on the line that have meaning in the context of the data. This application of linear functions naturally reinforces understanding of the family of linear functions and the properties of this family.

# Number and Quantity

## Signed Numbers

Understand rational numbers, both positive and negative

Order integers and rational numbers

Understand and order absolute values of rational numbers

## Real and Complex Numbers

Understand and use negative integer and zero exponents

Identify an irrational number

# Operations, Algebra, and Functions

## Ratio and Proportion

Understand ratio concepts

Solve ratio and rate problems

Interpret and represent ratios

Understand proportion concepts

Solve proportion problems

Interpret and represent proportions

## Expressions

Evaluate expressions at specific values of variables

Represent numbers in real-world or mathematical problems with variables

Generate equivalent expressions using arithmetic properties

Simplify expressions with rational coefficients and exponents

## Function Concepts

Understand how a function is defined

Graph functions and interpret their characteristics

Translate between different representations of linear relationships: graphs, equations, sets of ordered pairs, verbal descriptions, and tables

Find the rate of change and initial values from a table, graph, or verbal description

In a linear equation graphed on a coordinate plane, relate slopes and intercepts to their roles in the equation and verbal description

## Equations and Inequalities

Solve systems of linear equations

Solve one-step equations and inequalities and graph solutions

Solve two-step equations and inequalities and graph solutions

Solve multistep equations and inequalities and graph solutions

## Operations with Real and Complex Numbers

Simplify numbers or expressions involving exponents, roots, and scientific notation

Add, subtract, multiply, and divide expressions involving exponents, roots, and scientific notation

## Quadratic and Polynomial Equations and Functions

Recognize when data grows or lessens in a quadratic model

Solve quadratic equations using square roots, completing the square, and the quadratic formula

Solve quadratic equations, including those with complex and irrational roots

# Geometry and Measurement

## Plane Figures

Write and interpret symbolic notation for points, lines, line segments, and rays on a plane

Identify, draw, label, and use symbolic notation for special pairs of lines, line segments, and rays on a plane

Prove theorems about lines and angles

Solve problems represented on the coordinate plane

Use area formulas to construct a proof for the Pythagorean Theorem

### 3-Dimensional Figures

Use formulas to solve problems about packing volume of 3-D figures with rectangular, triangular, and circular bases and spheres

### Congruence, Similarity, and Transformations

Understand definitions and conditions of congruence viewed as transformations using rigid motion

Find measures of missing parts in congruent figures

Determine if two figures are similar

Find measures of missing parts in similar figures

Understand rotations, reflections, and dilations, reductions, and translations and their effects

Relate transformations to the coordinate plane

### Right Triangles

Use the Pythagorean Theorem to determine if a triangle is a right triangle

Find missing side lengths in a right triangle using the Pythagorean Theorem

Find distance between two points using the Pythagorean Theorem

## Statistics and Probability

### Descriptive Statistics

Create and understand dot plots, histograms, box-and-whisker plots, and stem-and-leaf plots, and use them to solve problems

Interpret center, spread, and shape of a distribution in context, including the effect of outliers

Read and interpret scatterplots, identifying clusters and associations

Create and interpret models of fit, both formally and informally

Understand the concept of correlation

Solve problems involving the association between categorical variables

### Set Theory and Logic

Use set theory concepts, including overlapping ovals, to solve problems

# Early High School

Students in early high school take the step from integer exponents to rational exponents, connecting exponents and radicals. Reasoning with rational exponents involves undefined cases. Reasoning about rational and irrational numbers also involves sophistication with set and subset relations as well as properties. Students begin to see equations with solutions outside the real number system—complex numbers to be explored later in high school.

Algebra involves understanding expressions and their parts, knowing what effect an algebraic operation has on the expressions and parts, and connecting the expressions and parts to mathematical and real-world contexts. Students also need to develop strategies for dealing with certain kinds of expressions and relations, such quadratic equations and exponential equations. Graphs provide a general way to understand expressions, relations, and functions, and also to picture solutions. Finding equivalent expressions will highlight properties of an expression, relation, or function if the parts have useful interpretations.

Students build a repertoire of useful strategies, and a sense of when to use them, through instruction, exploration, and repeated reasoning. A strategy for solving many problems becomes: make sense of the problem, abstract to find an equation, solve the equation, and interpret the solution(s) in the problem context. Students in high school become more powerful problem solvers by learning to solve more types of equations. Solving an equation is based on a process of reasoning, and students justify their reasoning as needed. Units of measure can also guide the solution process, providing opportunities to contextualize quantities. Students in early high school can make sense of derived quantities such as a change of 3 feet/second each second.

Students entering high school have seen many functions; they need not study entire function families before analyzing individual functions as long as they have the ability to get appropriate function values, for example, through a formula or with technology. Students can describe elements of the function by examining its graph or studying a table of values or reasoning about its equation. Students will study certain function families in high school, and through that study will develop specific interpretations of parts of the equations and of graph features. Rate of change characterizes some function families and is key to understanding calculus. For early high school, function families include the exponential functions and the quadratic functions in addition to the linear functions studied prior to high school.

While students coming into high school have a general idea about transformations, and about congruence and similarity, students in early high school make more precise and complete arguments to connect and apply these topics. Rigid motions (any combination of translation, rotation, and reflection) preserve size and shape, which gives congruence. Adding dilation to the mix still preserves shape, which yields similarity. An object with a line of symmetry is preserved by one or more reflections, and an object with rotational symmetry is preserved by a set of rotations. Congruence and similarity in terms of transformations give rise to conditions for having congruent and similar triangles. Congruence and similarity of polygons can be developed starting with triangles.

Students study and reason about categories of figures in order to express regularity and solve problems. In early high school, students study triangles, quadrilaterals, special polygons, and circles as well as configurations of lines, line segments, circles, and segments of circles.

Volume formulas have meaning, and students in early high school can give an informal argument justifying formulas for the circumference of a circle, the area of a circle, and the volume of a cylinder, pyramid, and cone. One very practical outcome is being able to solve measurement problems through geometric modeling. This also includes modeling in the coordinate plane, which opens up possibilities for using algebraic tools based on coordinates.

Students enter high school able to use and interpret various data representations and statistics. In early high school, they build up more function families to use for modeling data. They have an informal understanding of conditional probability and of defining compound events in terms of “and,” “or,” and “not,” preparing for more formalization of probability later in high school.

Students study randomization and recognize how it applies to sample surveys, experiments, and observational studies. Prior to high school, inferences were generally very clear-cut, and students in early high school develop techniques for making somewhat more subtle inferences, when results are somewhat mixed but there is still a strong signal. Later work in statistics will develop quantitative formulas to use when making inferences. In early high school, students discuss data collection and recognize common biases.

# Number and Quantity

## Counting and Cardinality

Understand and solve problems involving the Fundamental Counting Principle

## Signed Numbers

Understand rational numbers, both positive and negative

Order integers and rational numbers

Understand and order absolute values of rational numbers

## Real and Complex Numbers

Understand and use negative integer and zero exponents

Identify an irrational number

Understand and use rational exponents

# Operations, Algebra, and Functions

## Ratio and Proportion

Understand ratio concepts

Solve ratio and rate problems

Interpret and represent ratios

Understand proportion concepts

Solve proportion problems

Interpret and represent proportions

## Expressions

Evaluate expressions at specific values of variables

Represent numbers in real-world or mathematical problem with variables

Generate equivalent expressions using arithmetic properties

Simplify expressions with rational coefficients and exponents

## Function Concepts

Generate and identify rules of patterns

Understand how a function is defined

Graph functions and interpret their characteristics

Translate between different representations of linear relationships: graphs, equations, sets of ordered pairs, verbal descriptions, and tables

Transform a single function

Manipulate functions in equation form to find new functions

Find inverses and compositions of functions

Find the rate of change and initial values from a table, graph, or verbal description

In a linear equation graphed on a coordinate plane, relate slopes and intercepts to their roles in the equation and verbal description

## Equations and Inequalities

Solve systems of linear equations

Solve one-step equations and inequalities and graph solutions

Solve two-step equations and inequalities and graph solutions

Solve multistep equations and inequalities and graph solutions

Graph compound linear equations and inequalities

Solve and graph multistep and compound inequalities

## Operations with Real and Complex Numbers

Simplify numbers or expressions involving exponents, roots, and scientific notation

Add, subtract, multiply, and divide expressions involving exponents, roots, and scientific notation

## Exponential and Logarithmic Equations and Functions

Identify situations in which a quantity changes by a constant rate per unit interval relative to another

Model exponential relationships with functions

Solve equations with like bases

## Quadratic and Polynomial Equations and Functions

Recognize when data grows or lessens in a quadratic model

Create a quadratic function for data

Factor and solve factorable quadratic expressions and equations

Solve quadratic equations using square roots, completing the square, and the quadratic formula

Solve quadratic equations, including those with complex and irrational roots

Define polynomials and apply all four operations to them

Solve polynomial equations and apply solutions

## Radical, Rational, and Trigonometric Functions

Simplify expressions containing radical and rational terms

Create and solve radical and rational equations

## Sequences and Series

Model arithmetic and geometric sequences from descriptions or lists

Find missing values or sums of arithmetic or geometric sequences

# Geometry and Measurement

## Plane Figures

Prove relationships in and between geometric figures

Write and interpret symbolic notation for points, lines, line segments, and rays on a plane

Identify, draw, label, and use symbolic notation for special pairs of lines, line segments, and rays on a plane

Construct congruent angles and segments as well as parallel and perpendicular lines

Prove theorems about lines and angles

Identify points, lines, and angles within a circle

Construct points, lines, and angles within a circle

Construct inscribed regular polygons in circles

Use area formulas to construct a proof for the Pythagorean Theorem

## 3-Dimensional Figures

Understand and identify cross sections of three-dimensional figures

Find and use equations of conic sections

Use formulas to solve problems about packing volume of 3-D figures with rectangular, triangular, and circular bases and spheres

## Units of Measure

Know and use unit conversions to convert larger units to smaller units within a system

Know and use unit conversions to convert units within a system

Know and use unit conversions to convert units between two systems

## Congruence, Similarity, and Transformations

Understand definitions and conditions of congruence viewed as transformations using rigid motion

Find measures of missing parts in congruent figures

Determine if two figures are similar

Find measures of missing parts in similar figures

Understand rotations, reflections, and dilations, reductions, and translations and their effects

Relate transformations to the coordinate plane

## Right Triangles

Use the Pythagorean Theorem to determine if a triangle is a right triangle

Find missing side lengths in a right triangle using the Pythagorean Theorem

Find distance between two points using the Pythagorean Theorem

Solve problems involving 30-60-90 triangles

Solve problems involving 45-45-90 triangles

## Trigonometry

Find values for sine, cosine, and tangent and their inverses of angles in right triangles

# Statistics and Probability

## Descriptive Statistics

Create and understand dot plots, histograms, box-and-whisker plots, and stem-and-leaf plots, and use them to solve problems

Find measures of the center of a distribution

Find measures of the spread of a distribution

Describe the shape of a distribution and use it to analyze a dataset

Interpret center, spread, and shape of a distribution in context, including the effect of outliers

Read and interpret scatterplots, identifying clusters and associations

Create and interpret models of fit, both formally and informally

Understand the concept of correlation

Solve problems involving the association between categorical variables

## Inferential Statistics

Understand the relationship between population, sample, and sampling distribution

Identify and evaluate various sampling methods and types of statistical studies

Make inferences about and construct confidence intervals for parameters of a single population

Make inferences about and construct confidence intervals for parameters of two populations

## Probability

Calculate probabilities by constructing and analyzing sample spaces, and by using permutations and combinations

Assign empirical probabilities to events

Solve probability problems involving union, intersections, and complements of events

Solve problems involving concepts related to conditional probability

Understand random variables and their distributions

Understand and apply variance

## Set Theory and Logic

Use set theory concepts, including overlapping ovals, to solve problems

Understand and use set theory notation

Use formal logic rules to solve problems

# Appendix D

# ACT Aspire Grade Level Targets for Science

The ACT Aspire science tests assess and report on science knowledge, skills, and practices across three Reporting Categories:

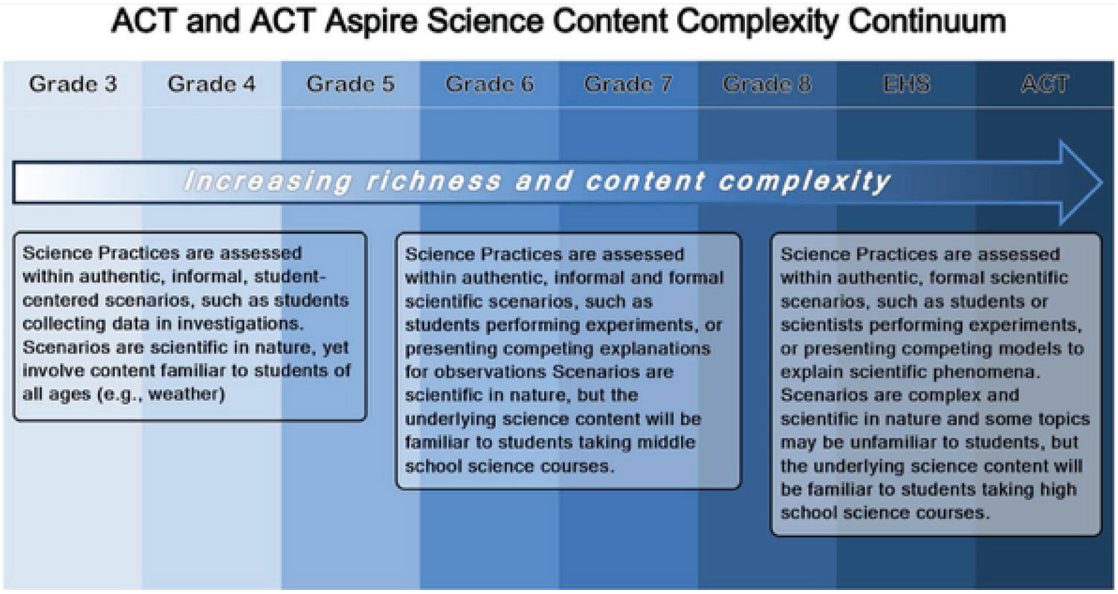
- **Interpretation of Data:** Students apply science knowledge, skills, and practices to locate, translate, infer and extend from, and evaluate data and information in scientific graphs, tables, and diagrams of varying complexity.
- **Scientific Investigation:** Students apply science knowledge, skills, and practices to understand the tools, procedures, and design of scientific experiments and to compare, extend, and modify those experiments
- **Evaluation of Models, Inferences, and Experimental Results:** Students apply science knowledge, skills, and practices to evaluate the validity of scientific information and formulate conclusions and predictions based on that information

These three Reporting Categories and the knowledge and skills encompassed in them are informed by ACT's decades of empirical data and research on college and career readiness in science and are derived directly from the ACT College and Career Readiness Standards for Science. The ACT College and Career Readiness Standards for science link specific skills and knowledge with quantitatively determined score ranges for the ACT science test and a benchmark science score that is predictive of success in science at the post-secondary level. All questions on the ACT Aspire science tests are based on authentic scientific scenarios that are built around important scientific concepts and are designed to mirror the experiences of students and working scientists engaging in real science. Some of the questions require that the students have discipline-specific content knowledge (e.g., for high school students, knowledge specific to an introductory high school physical science or biology course, which is part of the *ACT Aspire Science Content Domain*), but all of the questions focus on science skills and practices. ACT's research on science curricula and instruction at the high school and post-secondary levels shows that while science content is important, science skills and practices are more strongly tied to college and career readiness in science. The ACT Aspire science tests focus on measuring the science knowledge, skills, and practices that are empirically tied to college and career readiness in science.

ACT Aspire includes a standalone science test at each of the assessed grade level because years of assessing college and career readiness in science led to the conclusion that data from a few science-related questions on ELA and math tests do not provide the rich and accurate information that can be gleaned from a test that is solely focused on science.

# What is tested at the different grade levels of the ACT Aspire science tests?

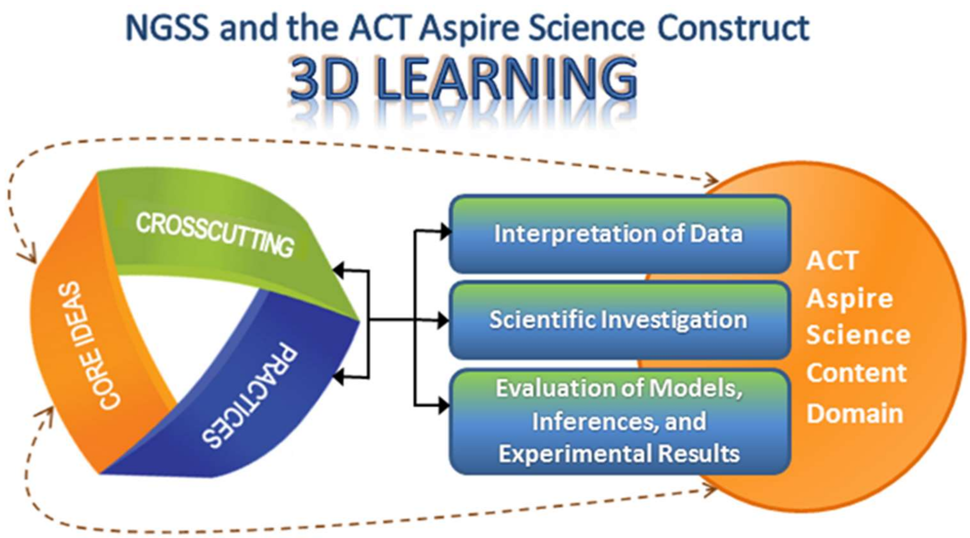
The skills assessed on ACT Aspire science tests are derived directly from the ACT College and Career Readiness Standards for science. These core skills are largely the same across the grade continuum. This is because our research shows that these core skills should be taught early and continually refined as a student progresses through school. What differs most from grade to grade in ACT Aspire science is the complexity of the content that makes up the contexts in which science skills and knowledge are assessed. The contexts used on the ACT Aspire science tests place the students in rich and authentic scientific scenarios that require that the students apply their knowledge and skills in science to both familiar and unfamiliar situations. As grade level increases, the scenarios have increasingly complex scientific graphics and experimental designs and are based on increasingly complex concepts. The students must then apply their knowledge and skills with increasing levels of sophistication. The amount of assumed discipline-specific science content knowledge that the students need to answer questions also increases. The following graphic illustrates this continuum (and includes the capstone ACT science test to which each grade of ACT Aspire is linked).




The body of knowledge and skills upon which the ACT Aspire science tests and the ACT Aspire Science College and Career Readiness Targets are focused, the *ACT Aspire Science College and Career Readiness Knowledge and Skills Domain*, present in Table XX of this appendix.

# How does the content of the ACT Aspire science tests relate to the NGSS?

The science knowledge, skills, and practices that are assessed on the ACT Aspire science tests are highly represented in the NGSS and are contained primarily in two of its three dimensions: *Science and Engineering Practices* and *Cross-Cutting Concepts*. They also reflect a major component of the NGSS Performance Expectations. While the ACT Aspire science tests are focused on science skills and practices, all questions are based on discipline-specific science content from the ACT Aspire Science Content Domain that encompasses the science content in the third dimension of the NGSS, the *Disciplinary Core Ideas*, which aligns highly with the NGSS philosophy of "3-dimensional learning." Measuring student performance at the intersection between science content and science skills and practices is central to the ACT Aspire science tests and to the NGSS.






A list of NGSS Performance Expectations is provided with each set of ACT Aspire Science College and Career Readiness Targets (the *NGSS LINK*) to provide a direct link between what is assessed on the ACT Aspire science tests and the NGSS.

# How are the ACT Aspire Science College and Career Readiness Targets Arranged?

The ACT Aspire Science College and Career Readiness Targets are arranged by grade band: Elementary School (Grades 3–5); Middle School (Grades 6–8); and Early High School (Grades 9–10). Within each grade band, they are arranged by grade, and then by Reporting Category (Interpretation of Data, Scientific Investigation, and then Evaluation of Models, Inferences, and Experimental Results). Within each Reporting Category are three Skill Areas, and each Skill Area contains several Skill Statements. For each grade, the Skill Statements are each assigned a target complexity level. The target corresponds to the level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill. There are three levels of complexity specific to the grade band: Simple, Moderately Complex, or Complex. It is important to note that the complexity level "Simple" at the elementary school level is not the same as the complexity level "Simple" at the high school level. The interpretations of these terms are described at the beginning of the section for each Reporting Category for each grade band. Each set of targets is followed by the *NGSS LINK*, which lists all of the NGSS Performance Expectations that are aligned to that Reporting Category. Because the NGSS is not separated by grade for the Middle and High School grade bands, all of the aligned Performance Expectations are listed for each grade in the grade band.

**Table A.D.1. ACT Aspire Science College and Career Readiness Knowledge and Skills Domain**

| Reporting Category | Skill Area | Skill Code | Skill Statement |
|---|---|---|---|
| Interpretation of Data (IOD) | Locating and Understanding | IOD-LU-01 | Select one piece of data from a data presentation |
| | | IOD-LU-02 | Find information in text that describes a data presentation |
| | | IOD-LU-03 | Select two or more pieces of data from a data presentation |
| | | IOD-LU-04 | Identify features of a table, graph, or diagram (e.g., axis labels, units of measure) |
| | | IOD-LU-05 | Understand common scientific terminology, symbols, and units of measure |
| | Inferring and Translating | IOD-IT-01 | Translate information into a table, graph, or diagram |
| | | IOD-IT-02 | Determine how the value of a variable changes as the value of another variable changes in a data presentation |
| | | IOD-IT-03 | Compare data from a data presentation (e.g., find the highest/lowest value; order data from a table) |
| | | IOD-IT-04 | Combine data from a data presentation (e.g., sum data from a table) |
| | | IOD-IT-05 | Compare data from two or more data presentations (e.g., compare a value in a table to a value in a graph) |
| | | IOD-IT-06 | Combine data from two or more data presentations (e.g., categorize data from a table using a scale from another table) |
| | | IOD-IT-07 | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) |
| | Extending and Reevaluating | IOD-ER-01 | Perform an interpolation using data in a table or graph |
| | | IOD-ER-02 | Perform an extrapolation using data in a table or graph |
| | | IOD-ER-03 | Analyze presented data when given new information (e.g., reinterpret a graph when new findings are provided) |

**Table A.D.1. ACT Aspire Science College and Career Readiness Knowledge and Skills Domain—continued**

| Reporting Category | Skill Area | Skill Code | Skill Statement |
|---|---|---|---|
| Scientific Investigation (SIN) | Locating and Comparing | SIN-LC-01 | Find information in text that describes an experiment |
| | | SIN-LC-02 | Identify similarities and differences between experiments |
| | | SIN-LC-03 | Determine which experiments utilized a given tool, method, or aspect of design |
| | Designing and Implementing | SIN-DI-01 | Understand the methods, tools, and functions of tools used in an experiment |
| | | SIN-DI-02 | Understand an experimental design |
| | | SIN-DI-03 | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) |
| | | SIN-DI-04 | Evaluate the design or methods of an experiment (e.g., possible flaws or inconsistencies; precision and accuracy issues) |
| | Extending and Improving | SIN-EI-01 | Predict the results of an additional trial or measurement in an experiment |
| | | SIN-EI-02 | Determine the experimental conditions that would produce specified results |
| | | SIN-EI-03 | Determine an alternate method for testing a hypothesis |
| | | SIN-EI-04 | Predict the effects of modifying the design or methods of an experiment |
| | | SIN-EI-05 | Determine which additional trial or experiment could be performed to enhance or evaluate experimental results |

**Table A.D.1. ACT Aspire Science College and Career Readiness Knowledge and Skills Domain—continued**

| Reporting Category | Skill Area | Skill Code | Skill Statement |
|---|---|---|---|
| Evaluation of Models, Inferences, and Experimental Results (EMI) | Inferences and Results: Evaluating and Extending | EMI-IE-01 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with a data presentation or piece of information in text |
| | | EMI-IE-02 | Determine which experimental results support or contradict a hypothesis, prediction, or conclusion |
| | | EMI-IE-03 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with two or more data presentations and/or pieces of information in text |
| | | EMI-IE-04 | Make a prediction and explain why it is consistent with a data presentation or piece of information in text |
| | | EMI-IE-05 | Explain why presented information, or new information, supports or contradicts a hypothesis or conclusion |
| | | EMI-IE-06 | Make a prediction and explain why it is consistent with two or more data presentations and/or pieces of information in text |
| | Models: Understanding and Comparing (Grades 6–12) | EMI-MU-01 | Find information in a theoretical model (a viewpoint proposed to explain scientific observations) |
| | | EMI-MU-02 | Identify implications and assumptions in a theoretical model |
| | | EMI-MU-03 | Determine which theoretical models present or imply certain information |
| | | EMI-MU-04 | Identify similarities and differences between theoretical models |
| | Models: Evaluating and Extending (Grades 6–12) | EMI-ME-01 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model |
| | | EMI-ME-02 | Determine which hypothesis, prediction, or conclusion is, or is not, consistent with two or more theoretical models |
| | | EMI-ME-03 | Identify the strengths and weaknesses of theoretical models |
| | | EMI-ME-04 | Determine which theoretical models are supported or weakened by new information |
| | | EMI-ME-05 | Determine which theoretical models support or contradict a hypothesis, prediction, or conclusion |
| | | EMI-ME-06 | Use new information to make a prediction based on a theoretical model |
| | | EMI-ME-07 | Explain why presented information, or new information, supports or weakens a theoretical model |
| | | EMI-ME-08 | Make a prediction and explain why it is consistent with a theoretical model |
| | | EMI-ME-09 | Make a prediction and explain why it is consistent with two or more theoretical models |

# Science Grade Level Learning Targets for Elementary School Grades 3–5

| | |
|---|---|
| **INTERPRETATION OF DATA** | Students apply science knowledge, skills, and practices to locate, translate, infer and extend from, and evaluate data and information in scientific graphs, tables, and diagrams of varying complexity. |

**Content complexity and how it relates to *Interpretation of Data* for the Elementary School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative content complexity of various elements of the stimulus material (e.g., the presented graphs, experiments, or models). For *Interpretation of Data*, the most relevant aspects of complexity are the scientific data presentations (tables, graphs, diagrams, etc.) upon which most skills in this category are based, and so the descriptions that follow serve as examples of how the terms *simple, moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 4th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptors are applied based on the perspective of elementary school (Grades 3–5) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities Represented by the Data Presentation | Types/Nature of the Data Presentation |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to elementary school students, even those who have had rigorous science instruction, such as density or concentration, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many elementary school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to elementary school students regardless of their exposure to rigorous science instruction, such as tables with shared and stacked headings, bar graphs with double bars and a legend, line graphs with more than one labeled line, tables with negative quantities, simple scatterplots, flow diagrams with multiple branching and multiple levels. |
| Moderately Complex | Concepts are likely to be familiar to an elementary school student who has had rigorous science instruction (but may not be to students lacking this instruction), such as mass, volume, or speed (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., plant height or volume of liquid added); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per bed or inches of rainfall per week. | Likely to be familiar to elementary school students who have had consistent exposure to rigorous science instruction, such as tables with three or more columns and single headings, bar graphs with several single bars, pictographs with icons representing a certain number of things (e.g., each bird in a pictograph equals 10 birds), very simple line graphs, flow diagrams with two or more levels (like a basic food web). |
| Simple | Concepts are likely to be familiar to, or readily understood by, elementary school students regardless of their exposure to rigorous science instruction (even if not fully understood, such as temperature) and are often numbers of things, like number of bugs or number of days. | Likely to be familiar to elementary school students regardless of their exposure to rigorous science instruction, such as tables with one or two columns and single headings, pictographs, line plots, bar graphs with a few single bars, linear flow diagrams (e.g., a short food chain). |

| Grade 3 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with elementary school-level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in introductory presentations of scientific data that are appropriate for elementary school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | ◀ | ● | ▶ |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | ◀ | ● | ▶ |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | ● | ▶ | |
| **Inferring and Translating:** Students should interpret and construct introductory scientific tables, graphs, and diagrams that are appropriate for elementary school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Some students may be ready to work with data across multiple scientific tables and graphs that are appropriate for elementary school students. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | ● | ▶ | |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | ● | ▶ | |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | ● | ▶ | |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | ● | ▶ | |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ▶ | | |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ▶ | | |
| | Determine and/or use a mathematical relationship that exists between data (e.g., finding the difference between two data points) *[IOD-IT-07]* | *Advanced skill for Grade 3 students* | | |

| Grade 3 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in introductory scientific graphs and tables that are appropriate for elementary school students to predict values that fall between known data points. Some students should try to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | ● | ▶ | |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ▶ | *Advanced skill for Grade 3 students* | |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ▶ | | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.*
*3-PS2-3: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.*
*3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.*
*3-LS2-1: Construct an argument that some animals form groups that help members survive.*
*3-LS3-1: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.*
*3-LS3-2: Use evidence to support the explanation that traits can be influenced by the environment.*
*3-LS4-1: Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.*
*3-LS4-2: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.*
*3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.*
*3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*
*3-ESS2-1: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.*
*3-ESS2-2: Obtain and combine information to describe climates in different regions of the world.*
*3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather- related hazard.*
*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*
*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

| Grade 4 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with elementary school-level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in basic presentations of scientific data that are appropriate for elementary school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | | ◀ | ● |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | | ◀ | ● |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | ◀ | ● | ▶ |
| **Inferring and Translating:** Students should interpret and construct basic scientific tables, graphs, and diagrams that are appropriate for elementary school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Many students will be ready to work with data across multiple scientific tables and graphs that are appropriate for elementary school students. Some students will begin to apply appropriate level of mathematics to elementary school-level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | ◀ | ● | ▶ |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | ◀ | ● | ▶ |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | ◀ | ● | ▶ |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | ◀ | ● | ▶ |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ● | ▶ | |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ● | ▶ | |
| | Determine and/or use a mathematical relationship that exists between data (e.g., finding the difference between two data points) *[IOD-IT-07]* | ▶ | | |

| Grade 4 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in basic scientific graphs and tables that are appropriate for elementary school students to predict values that fall between known data points. Many students should be able to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | ◀ | ● | ▶ |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ● | ▶ | |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ● | ▶ | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.*

*4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.*

*4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

*4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.*

*4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.*

*4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.*

*4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.*

*4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.*

*4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.*

*4-ESS2-2: Analyze and interpret data from maps to describe patterns of Earth's features.*

*4-ESS3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.*

*4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

| Grade 5 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with elementary school-level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in somewhat advanced presentations of scientific data that are appropriate for elementary school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | | | ◀ |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | | | ◀ |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | | ◀ | ● |
| **Inferring and Translating:** Students should interpret and construct somewhat advanced scientific tables, graphs, and diagrams that are appropriate for elementary school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Most students should be ready to work with data across multiple scientific tables and graphs that are appropriate for elementary school students. Students should regularly apply appropriate level of mathematics to elementary school-level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | | ◀ | ● |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | | ◀ | ● |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | | ◀ | ● |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | | ◀ | ● |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ◀ | ● | ▶ |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ◀ | ● | ▶ |
| | Determine and/or use a mathematical relationship that exists between data (e.g., finding the difference between two data points) *[IOD-IT-07]* | ● | ▶ | |

| Grade 5 Science Targets: Interpretation of Data | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in somewhat advanced scientific graphs and tables that are appropriate for elementary school students to predict values that fall between known data points. Most students should be ready to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | | ◀ | ● |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ◀ | ● | ▶ |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ◀ | ● | ▶ |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*5-PS1-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.*
*5-PS1-3: Make observations and measurements to identify materials based on their properties.*
*5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.*
*5-PS3-1: Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.*
*5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water.*
*5-ESS1-1: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.*
*5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
*5-ESS2-2: Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.*
*5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.*
*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*
*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

| | |
|---|---|
| **SCIENTIFIC INVESTIGATION** | Students apply science knowledge, skills, and practices to understand the tools, procedures, and design of scientific experiments and to compare, extend, and modify those experiments. |

**Content complexity and how it relates to *Scientific Investigation* for the Elementary School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple*, *moderately complex*, or *complex* are used to describe the relative complexity of various elements of the stimulus material (e.g., the presented graphs or experiments). For *Scientific Investigation*, the most relevant aspects of complexity are the experiments (a general term used here to mean any type of systematic investigation, even observational studies and other investigations that are not technically experiments) upon which most skills in this category are based, and so the descriptions that follow serve as examples of how the terms *simple*, *moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 4th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptors are applied based on the perspective of elementary school (Grades 3–5) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities in the Experiment | Experimental Design and Methods |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to elementary school students, even those who have had rigorous science instruction, such as density or concentration, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many elementary school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be challenging for elementary school students to follow, regardless of their level of experience engaging in science investigations, such as experiments having several, intricate steps and the number of variables measured and controlled being 4 or greater, often using unfamiliar, newly introduced methods and tools. |
| Moderately Complex | Concepts are likely to be familiar to an elementary school student who has had rigorous science instruction (but may not be to students lacking this instruction), such as mass, volume, or speed (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., plant height or volume of liquid added); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per bed or inches of rainfall per week. | Likely to be familiar to, or readily understood by, an elementary school student who has had consistent and well-guided opportunities to engage in science investigations (but may not be to students lacking this experience); examples include simple field studies in the playground involving defined test plots, experiments with several, straightforward steps in which the number of variables measured and controlled is 3 or fewer; methods and tools are very common, such as using a balance, graduated cylinder, or a heat source. |
| Simple | Concepts are likely to be familiar to, or readily understood by, elementary school students regardless of their exposure to rigorous science instruction (even if not fully understood, such as temperature) and are often numbers of things, like number of bugs or number of days. | Likely to be familiar to, or readily understood by, elementary school students, regardless whether a student has had consistent and well-guided opportunities to engage in science investigations; examples include recording insect activity in a backyard, experiments with only a few steps in which the one variable is measured and one (or none) is controlled; methods and tools are very common, such as counting, using a ruler, measuring weight. |

| Grade 3 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine introductory elementary school level investigations to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | ◀ | ● | ▶ |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | ◀ | ● | ▶ |
| **Designing and Implementing:** Students should examine introductory elementary school level investigations to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | ● | ▶ | |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | ● | ▶ | |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | ● | ▶ | |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ▶ | | |

| Grade 3 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from introductory elementary school level investigations to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Some students may be ready to explore revising and extending from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | ● | ▶ | |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ▶ | | |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | Advance skills for Grade 3 Students | | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | | | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.*

*3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.*

*3-PS2-3: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.*

*3-PS2-4: Define a simple design problem that can be solved by applying scientific ideas about magnets.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

*3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.*

| Grade 4 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine basic elementary school level investigations to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | | ◀ | ● |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | | ◀ | ● |
| **Designing and Implementing:** Students should examine basic elementary school level investigations to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | ◀ | ● | ▶ |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | ◀ | ● | ▶ |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | ◀ | ● | ▶ |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ● | ▶ | |

| Grade 4 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from basic elementary school level investigations to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Students should then revise and extend from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | ◀ | ● | ▶ |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ● | ▶ | |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | ▶ | | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | ▶ | | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | ▶ | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.*

*4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.*

*4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

*4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.*

*4-ESS2-1: Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.*

*4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

*3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.*

| Grade 5 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine elementary school level investigations that are somewhat advanced to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | | | ◀ |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | | | ◀ |
| **Designing and Implementing:** Students should examine elementary school level investigations that are somewhat advanced to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | | ◀ | ● |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | | ◀ | ● |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | | ◀ | ● |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ◀ | ● | ▶ |

| Grade 5 Science Targets: Scientific Investigation | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from elementary school level investigations that are somewhat advanced to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Students should then revise and extend from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | | ◀ | ● |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ◀ | ● | ▶ |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | ● | ▶ | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | ● | ▶ | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | ● | ▶ | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*5-PS1-2: Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.*

*5-PS1-3: Make observations and measurements to identify materials based on their properties.*

*5-PS1-4: Conduct an investigation to determine whether the mixing of two or more substances results in new substances.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

*3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.*

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| **EVALUATION OF MODELS, INFERENCES, AND EXPERIMENTAL RESULTS** | Students apply science knowledge, skills, and practices to evaluate the validity of scientific information and formulate conclusions and predictions based on that information |

**Content complexity and how it relates to *Evaluation of Models, Inferences, and Experimental Result*s for the Elementary School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex,* or *complex* are used to describe the relative content complexity of various elements of the stimulus material (e.g., the presented graphs and experiments). At the elementary school level, *Evaluation of Models, Inferences, and Experimental Results* focuses on the evaluation of data and experiments. Abbreviated explanations of how the complexity of contexts varies across Grades 3–5 are provided to describe how the terms *simple*, *moderately complex*, or *complex* are to be interpreted (more details about how these terms are applied to data presentations and experiments are provided in the *Interpretation of Data* and *Scientific Investigation* sections). What is simple or complex to a 4th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptor s are applied based on the perspective of elementary school (Grades 3–5) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Embedded Concepts and Quantities | Data Presentations and Experiments |
|---|---|---|
| Complex | Concepts are introduced to students may be unfamiliar to elementary school students, even those who have had rigorous science instruction, such as density or concentration, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many elementary school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to elementary school students regardless of their exposure to rigorous, active science instruction. Even advanced students may need to rely heavily on the provided explanations. |
| Moderately Complex | Concepts are likely to be familiar to an elementary school student who has had rigorous science instruction (but may not be to students lacking this instruction), such as mass, volume, or speed (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., plant height or volume of liquid added); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per bed or inches of rainfall per week. | Likely to be familiar to elementary school students who have had consistent exposure to rigorous, active science instruction but challenging to other elementary school students. |
| Simple | Concepts are likely to be familiar to, or readily understood by, elementary school students regardless of their exposure to rigorous science instruction (even if not fully understood, such as temperature) and are often numbers of things, like number of bugs or number of days. | Likely to be familiar to, or readily understood by, elementary school students regardless of their exposure to rigorous, active science instruction. |

| Grade 3 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine introductory sources of scientific information along with the results of their own elementary school level scientific investigations to evaluate claims and to make valid inferences, and some students may be ready to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | ● | ▶ | |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ▶ | | |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | Advance skills for Grade 3 Students | | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*3-PS2-3: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.*

*3-LS1-1: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.*

*3-LS2-1: Construct an argument that some animals form groups that help members survive.*

*3-LS3-2: Use evidence to support the explanation that traits can be influenced by the environment.*

*3-LS4-2: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.*

*3-LS4-3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.*

*3-LS4-4: Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*

*3-ESS3-1: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

| Grade 4 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine introductory sources of scientific information along with the results of their own elementary school level scientific investigations to evaluate claims and to make valid inferences, and some students will be ready to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | ◀ | ● | ▶ |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ● | ▶ | |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | ▶ | | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | ▶ | | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.*

*4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.*

*4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*

*4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.*

*4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.*

*4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.*

*4-LS1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.*

*4-LS1-2: Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.*

*4-ESS1-1: Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.*

*4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

| Grade 5 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Elementary School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine introductory sources of scientific information along with the results of their own elementary school level scientific investigations to evaluate claims, to make valid inferences, and to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | | ◀ | ● |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ◀ | ● | ▶ |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | ● | ▶ | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | ● | ▶ | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*5-PS1-1: Develop a model to describe that matter is made of particles too small to be seen.*

*5-PS2-1: Support an argument that the gravitational force exerted by Earth on objects is directed down.*

*5-PS3-1: Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.*

*5-LS1-1: Support an argument that plants get the materials they need for growth chiefly from air and water.*

*5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.*

*5-ESS1-1: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.*

*5-ESS2-1: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.*

*3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.*

*3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.*

# Science Grade Level Learning Targets for Early High School Grades 9–10

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|---|---|
| **INTERPRETATION OF DATA** | Students apply science knowledge, skills, and practices to locate, translate, infer and extend from, and evaluate data and information in scientific graphs, tables, and diagrams of varying complexity. |

**Content complexity and how it relates to *Interpretation of Data* for the High School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative content complexity of various elements of the stimulus material (e.g., the presented graphs, experiments, or models). For *Interpretation of Data*, the most relevant aspects of complexity are the scientific data presentations (tables, graphs, diagrams, etc.) upon which most skills in this category are based and so the descriptions that follow serve as examples of how the terms *simple, moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 10th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptors are applied based on the perspective of high school students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities Represented by the Data Presentation | Types/Nature of the Data Presentation |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to high school students, even those who have had rigorous science instruction, such as heat (enthalpy) of reaction ($\Delta H°$) or torque, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many high school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to high school students regardless of their exposure to rigorous science instruction, such as phase diagrams, titration curves, combination bar/line graphs with two *y*-axes, or graphs having logarithmic scales. |
| Moderately Complex | Concepts/quantities embedded: Concepts are likely to be familiar to high school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as momentum, freezing point depression, and reaction rate (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., genetic frequency, work). | Likely to be familiar to high school students who have had exposure to rigorous science instruction but challenging to other high school students, such as histograms, Venn diagrams, bar graphs with clusters of four or more bars and a legend, line graphs with several curves and a legend, line graphs with two *y*-axes, flow diagrams with decision points. |
| Simple | Concepts are likely to be familiar to, or readily understood by, high school students regardless of their exposure to rigorous science instruction, such as such as temperature, rainfall—or density and concentration (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., percent of offspring, angle of reflection); or numbers of things—or a simple quantity—per another, familiar quantity, like rotations per minute or number of lightning strikes per storm event. | Likely to be familiar to high school students regardless of their exposure to rigorous science instruction, such as tables with one or more columns and single headings, bar graphs with clusters of three or fewer bars and line graphs with three or fewer curves (with a legend, when needed), pie charts, flow diagrams (e.g., a food web). |

| Early High School Science Targets: Interpretation of Data | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with high school level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in somewhat advanced scientific data presentations that are appropriate for high school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | | ◀ | ● |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | | ◀ | ● |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | ◀ | ● | ▶ |
| **Inferring and Translating:** Students should interpret and construct somewhat advanced scientific tables, graphs, and diagrams that are appropriate for high school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Most students should be able to work with data across multiple scientific tables and graphs that are appropriate for high school students. Students should regularly apply an appropriate level of mathematics to high school level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | ◀ | ● | ▶ |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | ◀ | ● | ▶ |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | ◀ | ● | ▶ |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | ◀ | ● | ▶ |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ● | ▶ | |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ● | ▶ | |
| | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) *[IOD-IT-07]* | ● | ▶ | |

| Early High School Science Targets: Interpretation of Data | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in somewhat advanced scientific graphs and tables that are appropriate for high school students to predict values that fall between known data points. Many students will be able to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | ◀ | ● | ▶ |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ● | ▶ | |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ● | ▶ | |

| | |
|---|---|
| ◀ | Below target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.*

*HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.*

*HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.*

*HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.*

*HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*

*HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.*

*HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.*

*HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.*

*HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.*

*HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

*HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.*

*HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

*HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.*

*HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).*

*HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

*HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.*

*HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.*

*HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.*

*HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.*

*HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.*

*HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

*HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.*

*HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*

*HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.*

*HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.*

*HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.*

*HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.*

*HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.*

*HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.*

*HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.*

*HS-LS2-4: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.*

*HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.*

*HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.*

*HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

*HS-LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.*

*HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.*

*HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.*

*HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.*

*HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.*

*HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.*

*HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.*

*HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.*

*HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.*

*HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

*HS-ESS1-1: Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.*

*HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.*

*HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements.*

*HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.*

*HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.*

*HS-ESS1-6: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.*

*HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.*

*HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.*

*HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.*

*HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.*

*HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.*

*HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.*

*HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*

*HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.*

*HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

*HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.*

*HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.*

*HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*

*HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

*HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*

*HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.*

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| **SCIENTIFIC INVESTIGATION** | Students apply science knowledge, skills, and practices to understand the tools, procedures, and design of scientific experiments and to compare, extend, and modify those experiments. |

**Content complexity and how it relates to *Scientific Investigation* for the High School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative complexity of various elements of the stimulus material (e.g., the presented graphs or experiments). For *Scientific Investigation*, the most relevant aspects of complexity are the experiments (a general term used here to mean any type of systematic investigation, even observational studies and other investigations that are not technically experiments) upon which most skills in this category are based, and so the descriptions that follow serve as examples of how the terms *simple, moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 10th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptors are applied based on the perspective of high school students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities in the Experiment | Experimental Design and Methods |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to high school students, even those who have had rigorous science instruction, such as heat (enthalpy) of reaction ($\Delta H°$) or torque, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many high school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be challenging for high school students to follow, regardless of their level of experience engaging in science investigations, such as experiments having several, intricate steps and the number of variables measured and controlled being 6 or greater, with more than one of those variables being measured simultaneously; the experiments often employ unfamiliar, newly introduced methods and tools. |
| Moderately Complex | Concepts are likely to be familiar to high school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as momentum, freezing point depression, and reaction rate (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., genetic frequency, work). | Likely to be familiar to, or readily understood by, a high school student who has had consistent and well-guided opportunities to engage in science investigations (but may not be to students lacking this experience); examples include experiments having several, intricate steps with the number of variables measured and controlled being 5 or greater and that employ methods and tools such as burets, paper chromatography, simple circuits. |
| Simple | Concepts are likely to be familiar to, or readily understood by, high school students regardless of their exposure to rigorous science instruction, such as such as temperature, rainfall—or density and concentration, even if only understood qualitatively; newly introduced but readily understood quantities (e.g., percent of offspring, angle of reflection); or numbers of things—or a simple quantity—per another familiar quantity, like rotations per minute or number of lightning strikes per storm event. | Likely to be familiar to a high school student, even those who have not had consistent and well-guided opportunities to engage in science investigations; examples include field studies involving several test plots, experiments having several steps, some basic and some intricate, in which the number of variables measured and controlled is 4 or fewer; methods and tools include simple dilutions to vary concentration, using instrumentation (like a pH meter), sorting soils by particle size. |

| Early High School Science Targets: Scientific Investigation | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine high school level investigations that are somewhat advanced to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | | | ◀ |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | | ◀ | ● |
| **Designing and Implementing:** Students should examine high school level investigations that are somewhat advanced to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | ◀ | ● | ▶ |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | ◀ | ● | ▶ |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | ◀ | ● | ▶ |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ● | ▶ | |

| Early High School Science Targets: Scientific Investigation | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from high school level investigations that are somewhat advanced to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Some students may be ready to explore revising and extending from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | ◀ | ● | ▶ |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ● | ▶ | |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03*] | ▶ | | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | ▶ | | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | ▶ | | |

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| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

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| *HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.* |
| *HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.* |
| *HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* |
| *HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* |
| *HS-PS2-5: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.* |
| *HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* |
| *HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).* |
| *HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.* |
| *HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.* |
| *HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* |
| *HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.* |
| *HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* |
| *HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.* |
| *HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* |
| *HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.* |
| *HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.* |
| *HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.* |

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| **EVALUATION OF MODELS, INFERENCES, AND EXPERIMENTAL RESULTS** | Students apply science knowledge, skills, and practices to evaluate the validity of scientific information and formulate conclusions and predictions based on that information |

**Content complexity and how it relates to *Evaluation of Models, Inferences, and Experimental Results* for the High School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative complexity of various elements of the stimulus material (e.g., the presented graphs or experiments). Some parts of *Evaluation of Models, Inferences, and Experimental Results* focus on the evaluation of data and experiments, but other parts are specific to contexts in which students or scientists present different explanations—referred to here as *theoretical models*—to explain the same scientific observations. An abbreviated explanation of how the complexity of contexts at the high school level is provided to describe how the terms *simple, moderately complex*, or *complex* are to be interpreted (more details about how these terms are applied to data presentations and experiments are provided in the *Interpretation of Data* and *Scientific Investigation* sections). What is simple or complex to a 10th grader is different than what is simple or complex to, say, a 7th grader, and so these descriptors are applied based on the perspective of high school students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Embedded Concepts and Quantities | Data Presentations, Experiments, and Theoretical Models |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to high school students, even those who have had rigorous science instruction, such as heat (enthalpy) of reaction ($\Delta H°$) or torque, or concepts specific to complex scenarios that are fully explained in text but will be challenging to many high school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to high school students regardless of their exposure to rigorous, active science instruction. Even advanced students may need to rely heavily on the provided explanations. |
| Moderately Complex | Concepts are likely to be familiar to high school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as momentum, freezing point depression, and reaction rate (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., genetic frequency, work). | Likely to be familiar to high school students who have had consistent exposure to rigorous, active science instruction but challenging to other high school students. |

| Complexity Descriptor | Embedded Concepts and Quantities | Data Presentations, Experiments, and Theoretical Models |
|---|---|---|
| Simple | Concepts are likely to be familiar to, or readily understood by, high school students regardless of their exposure to rigorous science instruction, such as such as temperature, rainfall—or density and concentration, even if only understood qualitatively; newly introduced but readily understood quantities (e.g., percent of offspring, angle of reflection); or numbers of things—or a simple quantity—per another familiar quantity, like rotations per minute or number of lightning strikes per storm event. | Likely to be familiar to, or readily understood by, high school students regardless of their exposure to rigorous, active science instruction. |

| Early High School Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine reputable sources of scientific information along with the results of their own high school level scientific investigations to evaluate claims and to make valid inferences. Some students will be ready to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | ◀ | ● | ▶ |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ● | ▶ | |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | ▶ | | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | ▶ | | |

| Early High School Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of High School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Models–Understanding & Comparing:** High school students should examine somewhat intricate competing models proposed to explain a scientific phenomenon to determine each model's key assertions and discern matters on which those models agree or disagree. | Find key facts and data cited in a theoretical model (a viewpoint proposed to explain scientific observations) *[EMI-MU-01]* | | | ◀ |
| | Examine theoretical models to identify and understand key scientific assumptions and implications *[EMI-MU-02,03]* | | ◀ | ● |
| | Compare competing theoretical models to determine key similarities and differences in how they explain scientific observations *[EMI-MU-04]* | ◀ | ● | ▶ |
| **Models–Evaluating & Extending:** High school students will encounter competing models of varying intricacy proposed to explain a scientific phenomenon. Students should evaluate the relative strengths and weaknesses of competing models, and some students will be ready to use models to construct their own predictions and conclusions. | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model *[EMI-ME-01]* | ◀ | ● | ▶ |
| | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with two or more competing theoretical models *[EMI-ME-02,05]* | ● | ▶ | |
| | Evaluate the strengths and weaknesses of theoretical models *[EMI-ME-03]* | ● | ▶ | |
| | Evaluate the impact of new findings on competing theoretical models *[EMI-ME-04]* | ● | ▶ | |
| | Construct and present an explanation for why scientific data supports or weakens a theoretical model *[EMI-ME-07]* | ▶ | | |
| | Make and defend a prediction based on one or more theoretical models *[EMI-ME-06,08,09]* | ▶ | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

NGSS LINK

HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3: Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.
HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

*HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.*

*HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*

*HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.*

*HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.*

*HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.*

*HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.*

*HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.*

*HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.*

*HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.*

*HS-LS2-4: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.*

*HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.*

*HS-LS2-6: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.*

*HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

*HS-LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.*

*HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.*

*HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.*

*HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.*

*HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.*

*HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.*

*HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.*

*HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

*HS-ESS1-1: Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.*

*HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.*

*HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements.*

*HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.*

*HS-ESS1-6: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.*

*HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.*

*HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.*

*HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.*

*HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.*

*HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.*

*HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*

*HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.*

*HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

*HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.*

*HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.*

*HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*

*HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

*HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*

*HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.*

# Science Grade Level Learning Targets for Middle School Grades 6–8

| | |
|---|---|
| **INTERPRETATION OF DATA** | Students apply science knowledge, skills, and practices to locate, translate, infer and extend from, and evaluate data and information in scientific graphs, tables, and diagrams of varying complexity. |

**Content complexity and how it relates to *Interpretation of Data* for the Middle School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative content complexity of various elements of the stimulus material (e.g., the presented graphs, experiments, or models). For *Interpretation of Data*, the most relevant aspects of complexity are the data presentations (tables, graphs, diagrams, etc.) upon which most skills in this category are based, and so the descriptions that follow serve as examples of how the terms *simple, moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 7th grader is different than what is simple or complex to, say, a 4th grader, and so these descriptors are applied based on the perspective of middle school (Grades 6–8) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities Represented by the Data Presentation | Types/Nature of the Data Presentation |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to middle school students, even those who have had rigorous science instruction, such as acceleration or $\Delta T$, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many middle school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to middle school students regardless of their exposure to rigorous science instruction, such as histograms, Venn diagrams, bar graphs with clusters of 4 or more bars and a legend, line graphs with more than three lines and a legend, tables with negative numbers, line graphs with two *y*-axes, flow diagrams with decision points. |
| Moderately Complex | Concepts are likely to be familiar to middle school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as density, pressure, and concentration (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., average particle diameter or root biomass). | Likely to be familiar to middle school students who have had exposure to rigorous science instruction but challenging to other middle school students, such as tables with shared and stacked headings, bar graphs with triple bars and a legend, line graphs with two or three lines and a legend, bar or line graphs with negative quantities, scatterplots, flow diagrams with multiple branching and multiple levels. |
| Simple | Concepts are likely to be familiar to, or readily understood by, middle school students regardless of their exposure to rigorous science instruction, such as mass, volume, or speed, (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., average gestation period or exposure time); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per pot or inches of rainfall per week. | Likely to be familiar to middle school students regardless of their exposure to rigorous science instruction, such as tables with one or more columns and single headings, bar graphs with single bars or double bars and a legend, pie charts, very simple line graphs, simple flow diagrams (like a basic food web). |

| Grade 6 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with middle school level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in basic scientific data presentations that are appropriate for middle school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | ◀ | ● | ▶ |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | ◀ | ● | ▶ |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | ● | ▶ | |
| **Inferring and Translating:** Students should interpret and construct basic scientific tables, graphs, and diagrams that are appropriate for middle school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Some students may be ready to work with data across multiple scientific tables and graphs that are appropriate for middle school students. Some students will begin to apply appropriate level of mathematics to middle school level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | ● | ▶ | |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | ● | ▶ | |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | ● | ▶ | |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | ● | ▶ | |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ▶ | | |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ▶ | | |
| | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) *[IOD-IT-07]* | ▶ | | |

| Grade 6 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in basic scientific graphs and tables that are appropriate for middle school students to predict values that fall between known data points. Some students may be able to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | ● | ▶ | |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ▶ | | |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ▶ | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.*
*MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.*
*MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*
*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*
*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*
*MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.*
*MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.*
*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
*MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*
*MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.*
*MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.*
*MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.*

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| *MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*<br>*MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.*<br>*MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*<br>*MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.*<br>*MS-LS1-8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.*<br>*MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.*<br>*MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.*<br>*MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*<br>*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*<br>*MS-LS4-1: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.*<br>*MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*<br>*MS-LS4-3: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.*<br>*MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.*<br>*MS-LS4-5: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.*<br>*MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.* |

*MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.*

*MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system.*

*MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.*

*MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*

*MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*

*MS-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.*

*MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*

*MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 7 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with middle school level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in somewhat advanced scientific data presentations that are appropriate for middle school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | | ◀ | ● |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | | ◀ | ● |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | ◀ | ● | ▶ |
| **Inferring and Translating:** Students should interpret and construct somewhat advanced scientific tables, graphs, and diagrams that are appropriate for middle school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Many students should be able to work with data across multiple scientific tables and graphs that are appropriate for middle school students. Many students should regularly apply appropriate level of mathematics to middle school level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | ◀ | ● | ▶ |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | ◀ | ● | ▶ |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | ◀ | ● | ▶ |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | ◀ | ● | ▶ |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ● | ▶ | |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ● | ▶ | |
| | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) *[IOD-IT-07]* | ● | ▶ | |

| Grade 7 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in somewhat advanced scientific graphs and tables that are appropriate for middle school students to predict values that fall between known data points. Many students will be able to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | ◀ | ● | ▶ |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ● | ▶ | |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ● | ▶ | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

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*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*
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*MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

*MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.*

*MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*

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*MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.*

*MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-LS4-1: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.*

*MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*

*MS-LS4-3: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.*

*MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.*

*MS-LS4-5: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.*

*MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.*

*MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.*

*MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system.*

*MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.*

*MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*

*MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*

*MS-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.*

*MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*

*MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 8 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Understanding:** While learning key concepts in the life, Earth/space, and physical sciences, students should work with middle school level scientific text, tables, graphs, and diagrams while learning and engaging in science. Students should become familiar with the conventions for presenting scientific information and be able to locate data in advanced scientific data presentations that are appropriate for middle school students. | Determine what is being represented by a scientific table, graph, or diagram and then locate relevant pieces of the displayed data *[IOD-LU-01,02,03]* | | | ◀ |
| | Identify and describe the features of scientific tables, graphs, and diagrams (e.g., axis labels, units of measure) *[IOD-LU-04]* | | | ◀ |
| | Understand and properly use common scientific terminology, symbols, and units of measure when engaging in science *[IOD-LU-05]* | | ◀ | ● |
| **Inferring and Translating:** Students should interpret and construct advanced scientific tables, graphs, and diagrams that are appropriate for middle school students to find trends and relationships, compare and combine data within data displays, and convert data from one type of display to another. Most students should be able to work with data across multiple scientific tables and graphs that are appropriate for middle school students. Most students should regularly apply appropriate level of mathematics to middle school level scientific data. | Translate scientific information into a table, graph, or diagram (e.g., convert tabular data into a graph) *[IOD-IT-01]* | | ◀ | ● |
| | Determine how the value of a variable changes as the value of another variable changes in a scientific table, graph, or diagram *[IOD-IT-02]* | | ◀ | ● |
| | Make meaningful comparisons between data in a scientific graph, table, or diagram (e.g., find the highest/lowest value; order data from a table) *[IOD-IT-03]* | | ◀ | ● |
| | Combine data from a scientific graph, table, or diagram in meaningful ways (e.g., summing daily measurements to obtain a weekly total) *[IOD-IT-04]* | | ◀ | ● |
| | Make meaningful comparisons across data located in separate scientific graphs, tables, or diagrams (e.g., compare a value in a table to a value in a related graph) *[IOD-IT-05]* | ◀ | ● | ▶ |
| | Combine data from two different scientific graphs, tables, or diagrams in meaningful ways (e.g., categorize data from a table using a scale found in another table) *[IOD-IT-06]* | ◀ | ● | ▶ |
| | Determine and/or use a mathematical relationship that exists between data (e.g., averaging data, unit conversions) *[IOD-IT-07]* | ◀ | ● | ▶ |

| Grade 8 Science Targets: Interpretation of Data | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Reevaluating:** Students should examine trends in advanced scientific graphs and tables that are appropriate for middle school students to predict values that fall between known data points. Most students should be ready to predict values that are beyond the range of presented data and to apply new findings to their interpretations. | Examine trends in a scientific table or graph to estimate a value or range of values that falls between two known values (interpolation) *[IOD-ER-01]* | | ◀ | ● |
| | Examine trends in a scientific table or graph to estimate a value or range of values that extends beyond the set of known values (extrapolation) *[IOD-ER-02]* | ◀ | ● | ▶ |
| | Use new findings to reevaluate interpretations of scientific data *[IOD-ER-03]* | ◀ | ● | ▶ |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.*
*MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.*
*MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*
*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs therma energy by chemical processes.*
*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic force*
*MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.*
*MS-PS3-1: Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.*
*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
*MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*
*MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.*

*MS-PS4-1: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.*

*MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.*

*MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

*MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.*

*MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*

*MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.*

*MS-LS1-8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.*

*MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.*

*MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.*

*MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-LS4-1: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.*

*MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*

*MS-LS4-3: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.*

*MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.*

*MS-LS4-5: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.*

*MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.*

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| *MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.*<br>*MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system.*<br>*MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.*<br>*MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*<br>*MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*<br>*MS-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.*<br>*MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*<br>*MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.*<br>*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*<br>*MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.*<br>*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*<br>*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*<br>*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*<br>*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.* |

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| **SCIENTIFIC INVESTIGATION** | Students apply science knowledge, skills, and practices to understand the tools, procedures, and design of scientific experiments and to compare, extend, and modify those experiments. |

**Content complexity and how it relates to *Scientific Investigation* for the Middle School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative complexity of various elements of the stimulus material (e.g., the presented graphs or experiments). For *Scientific Investigation*, the most relevant aspects of complexity are the experiments (a general term used here to mean any type of systematic investigation, even observational studies and other investigations that are not technically experiments) upon which most skills in this category are based, and so the descriptions that follow serve as examples of how the terms *simple, moderately complex*, or *complex* are to be interpreted. What is simple or complex to a 7th grader is different than what is simple or complex to, say, a 4th grader, and so these descriptors are applied based on the perspective of middle school (Grades 6–8) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Concepts/Quantities in the Experiment | Experimental Design and Methods |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to middle school students, even those who have had rigorous science instruction, such as acceleration or $\Delta T$, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many middle school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be challenging for middle school students to follow, regardless of their level of experience engaging in science investigations, such as experiments having several, intricate steps and the number of variables measured and controlled being 5 or greater, often using unfamiliar, newly introduced methods and tools. |
| Moderately Complex | Concepts are likely to be familiar to middle school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as density, pressure, and concentration (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., average particle diameter or root biomass). | Likely to be familiar to, or readily understood by, a middle school student who has had consistent and well-guided opportunities to engage in science investigations (but may not be to students lacking this experience); examples include field studies involving several test plots, experiments having several steps, some basic and some intricate, in which the number of variables measured and controlled is 4 or fewer; methods and tools include simple dilutions to vary concentration, using instrumentation (like a pH meter), sorting soils by particle size. |
| Simple | Concepts are likely to be familiar to, or readily understood by, middle school students regardless of their exposure to rigorous science instruction, such as mass, volume, or speed, even if only understood qualitatively; newly introduced but readily understood quantities (e.g., average gestation period or exposure time); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per pot or inches of rainfall per week. | Likely to be familiar to a middle school student, even those who have not had consistent and well-guided opportunities to engage in science investigations; examples include simple field studies involving test plots, experiments having several, straightforward steps in which the number of variables measured and controlled is 3 or fewer; methods and tools are very common, such as using a balance, graduated cylinder, or a heat source. |

| Grade 6 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine middle school level investigations of basic nature to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | | ◀ | ● |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | ◀ | ● | ▶ |
| **Designing and Implementing:** Students should examine middle school level investigations of basic nature to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | ● | ▶ | |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | ● | ▶ | |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | ● | ▶ | |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ▶ | Grade 6 students should be able to apply these skills to elementary-school-level investigations | |

| Grade 6 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from middle school level investigations of basic nature to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. When working with elementary school level materials, students should be able to revise and extend from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | ● | ▶ | |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ▶ | | |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | Grade 6 students should be able to apply these skills to elementary-school-level investigations | | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | | | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | | | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*
*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
*MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*
*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*
*MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.*
*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
*MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*

*MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 7 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine middle school level investigations that are somewhat advanced to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | | | ◀ |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | | ◀ | ● |
| **Designing and Implementing:** Students should examine middle school level investigations that are somewhat advanced to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | ◀ | ● | ▶ |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | ◀ | ● | ▶ |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | ◀ | ● | ▶ |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ● | ▶ | |

| Grade 7 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from middle school level investigations that are somewhat advanced to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Some students may be ready to explore revising and extending from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | ◀ | ● | ▶ |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ● | ▶ | |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | ▶ | | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | ▶ | | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | ▶ | | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

NGSS LINK

*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*
*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
*MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*
*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*
*MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.*
*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*
*MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*
*MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 8 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Locating and Comparing:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine middle school level investigations that are advanced to determine why they were carried out and what facts underlie the investigation, and to compare and contrast the elements of the different experiments that make up an investigation. | Examine the procedure for a scientific experiment to locate key concepts needed to understand what is being investigated *[SIN-LC-01]* | Skill to be mastered in early middle school | | |
| | Examine a set of related scientific experiments to identify similarities and differences in their designs, methods, and tools *[SIN-LC-02,03]* | | | ◀ |
| **Designing and Implementing:** Students should examine middle school level investigations that are advanced to identify the experimental hypothesis, controls, and variables, and what methods and tools were used to carry out the investigation. Students should understand why these design aspects and procedures were used, and whether those choices best served the intent of the investigation, and apply their findings to design and carry out their own investigations. | Understand the methods, tools, and functions of tools used in an experiment *[SIN-DI-01]* | | ◀ | ● |
| | Understand the design of an experiment (e.g., controls, independent and dependent variables) *[SIN-DI-02]* | | ◀ | ● |
| | Determine the scientific question that is the basis for an experiment (e.g., the hypothesis) and formulate a testable question for one's own investigation *[SIN-DI-03]* | | ◀ | ● |
| | Evaluate the design and methods used in an experiment (e.g., possible flaws, precision and accuracy issues) *[SIN-DI-04]* | ◀ | ● | ▶ |

| Grade 8 Science Targets: Scientific Investigation | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Extending and Improving:** Students should examine the results and procedures from middle school level investigations that are advanced to predict how changing the value of a variable or altering the experimental design will produce new results or allow new questions to be addressed. Students will be ready to explore revising and extending from their investigations and carry out new investigations that more fully address the questions they seek to answer. | Examine the results of an investigation to predict the result of an additional trial or measurement in an experiment *[SIN-EI-01]* | | ◀ | ● |
| | Examine the results of an investigation to predict the experimental conditions that would produce a desired result *[SIN-EI-02]* | ◀ | ● | ▶ |
| | Propose a valid alternate method for testing a hypothesis *[SIN-EI-03]* | ● | ▶ | |
| | Predict the effects of modifying the design or methods of an experiment *[SIN-EI-04]* | ● | ▶ | |
| | Determine which additional trial or experiment could be performed to enhance or evaluate the results of an experiment *[SIN-EI-05]* | ● | ▶ | |

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|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*

*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*

*MS-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.*

*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*

*MS-PS2-5: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.*

*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

*MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.*

*MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

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|---|---|
| **EVALUATION OF MODELS, INFERENCES, AND EXPERIMENTAL RESULTS** | Students apply science knowledge, skills, and practices to evaluate the validity of scientific information and formulate conclusions and predictions based on that information |

**Content complexity and how it relates to *Evaluation of Models, Inferences, and Experimental Results* for the Middle School Level**

Science knowledge, skills, and practices are assessed within increasingly complex scientific contexts with each successive grade level. The terms *simple, moderately complex*, or *complex* are used to describe the relative content complexity of various elements of the stimulus material (e.g., the presented graphs, experiments, or models). Some parts of *Evaluation of Models, Inferences, and Experimental Results* focus on the evaluation of data and experiments, but other parts are specific to contexts in which students or scientists present different explanations—referred to here as *theoretical models*—to explain the same scientific observations. An abbreviated explanation of how the complexity of contexts varies across Grades 6–8 is provided to describe how the terms *simple, moderately complex*, or *complex* are to be interpreted (more details about how these terms are applied to data presentations and experiments are provided in the *Interpretation of Data* and *Scientific Investigation* sections). What is simple or complex to a 7th grader is different than what is simple or complex to, say, a 4th grader, and so these descriptors are applied based on the perspective of middle school (Grades 6–8) students only and are meant as general guides rather than strict boundaries.

| Complexity Descriptor | Embedded Concepts and Quantities | Data Presentations, Experiments, and Theoretical Models |
|---|---|---|
| Complex | Concepts are introduced to students and may be unfamiliar to middle school students, even those who have had rigorous science instruction, such as acceleration or $\Delta T$, or concepts specific to complex scenarios that are fully explained in the text but will be challenging to many middle school students. Students of all levels will likely need to rely heavily on the explanations and definitions provided. | May be unfamiliar to middle school students regardless of their exposure to rigorous, active science instruction. Even advanced students may need to rely heavily on the provided explanations. |
| Moderately Complex | Concepts are likely to be familiar to middle school students who have had rigorous science instruction (but may not be to students lacking this instruction), such as density, pressure, and concentration (even if only understood qualitatively); newly introduced but readily understood quantities (e.g., average particle diameter or root biomass). | Likely to be familiar to middle school students who have had consistent exposure to rigorous, active science instruction but challenging to other middle school students. |
| Simple | Concepts are likely to be familiar to, or readily understood by, middle school students regardless of their exposure to rigorous science instruction, such as mass, volume, or speed, even if only understood qualitatively; newly introduced but readily understood quantities (e.g., average gestation period or exposure time); or a simple quantity (or number of things) per another familiar quantity, like number of flowers per pot or inches of rainfall per week. | Likely to be familiar to, or readily understood by, middle school students regardless of their exposure to rigorous, active science instruction. |

| Grade 6 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine reputable sources of scientific information along with the results of their own middle-school-level scientific investigations to evaluate claims and to make valid inferences. When working with elementary-school-level materials, student should be able to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | ● | ▶ | |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ▶ | | |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | Advanced skills that most Grade 6 students should be able to apply to elementary-school-level scientific information | | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | | | |
| **Models–Understanding & Comparing:** Middle school students should examine simple competing models proposed to explain a scientific observation to determine each model's key assertions and discern matters on which those models agree or disagree. | Find key facts and data cited in a theoretical model (a viewpoint proposed to explain scientific observations) *[EMI-MU-01]* | | ◀ | ● |
| | Examine theoretical models to identify and understand key scientific assumptions and implications *[EMI-MU-02,03]* | ◀ | ● | ▶ |
| | Compare competing theoretical models to determine key similarities and differences in how they explain scientific observations *[EMI-MU-04]* | ● | ▶ | |

| Grade 6 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| **Skill Area** | **Skill Statement** | **Simple** | **Moderately Complex** | **Complex** |
| **Models–Evaluating & Extending:** Middle school students will encounter competing models of varying intricacy proposed to explain a scientific observation. Students should evaluate the relative strengths and weaknesses of competing models, and when working with elementary school level materials, use models to construct their own predictions and conclusions. | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model *[EMI-ME-01]* | ● | ▶ | |
| | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with two or more competing theoretical models *[EMI-ME-02,05]* | ▶ | | |
| | Evaluate the strengths and weaknesses of theoretical models *[EMI-ME-03]* | ▶ | | |
| | Evaluate the impact of new findings on competing theoretical models *[EMI-ME-04]* | ▶ | | |
| | Construct and present an explanation for why scientific data supports or weakens a theoretical model *[EMI-ME-07]* | Advanced skills that most Grade 6 students should be able to apply elementary-school-level scientific information | | |
| | Make and defend a prediction based on one or more theoretical models *[EMI-ME-06,08,09]* | | | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

**NGSS LINK**

*MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.*

*MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*

*MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.*

*MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.*

*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*

*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*

*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*

*MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.*

*MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.*

*MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

*MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.*

*MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.*

*MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.*

*MS-LS1-2: Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.*

*MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

*MS-LS1-4: Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.*

*MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*

*MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.*

*MS-LS1-7: Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.*

*MS-LS1-8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.*

*MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.*

*MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.*

*MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

*MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

*MS-LS3-1: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.*

*MS-LS3-2: Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.*

*MS-LS4-2: Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.*

*MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.*

*MS-LS4-5: Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.*

*MS-LS4-6: Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.*

*MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.*

*MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.*

*MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.*

*MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*

*MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*

*MS-ESS2-4: Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.*

*MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.*

*MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.*

*MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*

*MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.*

*MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 7 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| Skill Area | Skill Statement | Simple | Moderately Complex | Complex |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine reputable sources of scientific information along with the results of their own middle school level scientific investigations to evaluate claims and to make valid inferences. Some students will be ready to generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | ◀ | ● | ▶ |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ● | ▶ | |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | ▶ | | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | ▶ | | |
| **Models–Understanding & Comparing:** Middle school students should examine somewhat intricate competing models proposed to explain a scientific observation to determine each model's key assertions and discern matters on which those models agree or disagree. | Find key facts and data cited in a theoretical model (a viewpoint proposed to explain scientific observations) *[EMI-MU-01]* | | | ◀ |
| | Examine theoretical models to identify and understand key scientific assumptions and implications *[EMI-MU-02,03]* | | ◀ | ● |
| | Compare competing theoretical models to determine key similarities and differences in how they explain scientific observations *[EMI-MU-04]* | ◀ | ● | ▶ |
| **Models–Evaluating & Extending:** Middle school students will encounter competing models of varying intricacy proposed to explain a scientific observation. Students should evaluate the relative strengths and weaknesses of competing models, and some students will be ready to use models to construct their own predictions and conclusions. | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model *[EMI-ME-01]* | ◀ | ● | ▶ |
| | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with two or more competing theoretical models *[EMI-ME-02,05]* | ● | ▶ | |
| | Evaluate the strengths and weaknesses of theoretical models *[EMI-ME-03]* | ● | ▶ | |
| | Evaluate the impact of new findings on competing theoretical models *[EMI-ME-04]* | ● | ▶ | |
| | Construct and present an explanation for why scientific data supports or weakens a theoretical model *[EMI-ME-07]* | ▶ | | |
| | Make and defend a prediction based on one or more theoretical models *[EMI-ME-06,08,09]* | ▶ | | |

| | |
|---|---|
| ◀ | Approaching target level |
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

*MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.*

*MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*

*MS-PS1-4: Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.*

*MS-PS1-5: Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.*

*MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*

*MS-PS2-1: Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*

*MS-PS2-3: Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.*

*MS-PS2-4: Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.*

*MS-PS3-2: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.*

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*MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.*

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*MS-ESS2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.*

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*MS-ESS3-5: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*

*MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*

*MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*

*MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

*MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.*

| Grade 8 Science Targets: Evaluation of Inferences, Models, and Experiments | | Complexity of Middle School Level Scientific Content | | |
|---|---|---|---|---|
| **Skill Area** | **Skill Statement** | **Simple** | **Moderately Complex** | **Complex** |
| **Inferences & Results–Evaluating & Extending:** While learning key concepts in the life, Earth/space, and physical sciences, students should examine reputable sources of scientific information along with the results of their own middle school level scientific investigations to evaluate claims, to make valid inferences, and to and generate and defend their own claims. | Examine a source of scientific data to evaluate whether the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-01,02]* | | ◀ | ● |
| | Examine multiple sources of scientific data to evaluate whether some or all of the data supports or contradicts a scientific hypothesis, prediction, or conclusion *[EMI-IE-03]* | ◀ | ● | ▶ |
| | Evaluate a proposed scientific hypothesis or conclusion and explain why it is, or is not, supported by the findings of scientific investigations *[EMI-IE-05]* | ● | ▶ | |
| | Make a prediction and explain why it is consistent with the findings of scientific investigations *[EMI-IE-04,06]* | ● | ▶ | |
| **Models–Understanding & Comparing:** Middle school students should examine intricate competing models proposed to explain a scientific observation to determine each model's key assertions and discern matters on which those models agree or disagree. | Find key facts and data cited in a theoretical model (a viewpoint proposed to explain scientific observations) *[EMI-MU-01]* | Skill to be mastered in early middle school | | |
| | Examine theoretical models to identify and understand key scientific assumptions and implications *[EMI-MU-02,03]* | | | ◀ |
| | Compare competing theoretical models to determine key similarities and differences in how they explain scientific observations *[EMI-MU-04]* | | ◀ | ● |
| **Models–Evaluating & Extending:** Middle school students will encounter competing models of varying intricacy proposed to explain a scientific observation. Students should evaluate the relative strengths and weaknesses of competing models, and use models to construct their own predictions and conclusions. | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with a theoretical model *[EMI-ME-01]* | | ◀ | ● |
| | Determine whether a proposed hypothesis, prediction, or conclusion is, or is not, consistent with two or more competing theoretical models *[EMI-ME-02,05]* | ◀ | ● | ▶ |
| | Evaluate the strengths and weaknesses of theoretical models *[EMI-ME-03]* | ◀ | ● | ▶ |
| | Evaluate the impact of new findings on competing theoretical models *[EMI-ME-04]* | ◀ | ● | ▶ |
| | Construct and present an explanation for why scientific data supports or weakens a theoretical model *[EMI-ME-07]* | ● | ▶ | |
| | Make and defend a prediction based on one or more theoretical models *[EMI-ME-06,08,09]* | ● | ▶ | |

◀ Approaching target level

| | |
|---|---|
| ● | **Target level of complexity of the science content to which students who are on track to be college and career ready should be consistently applying this skill** |
| ▶ | Exceeding target level |

*MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures.*

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*MS-ESS2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.*
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# Appendix E

# ACT Aspire Scaling Study

This appendix presents the vertical scaling process for the four ACT Aspire subject tests: English, mathematics, reading, and science. The ACT Aspire assessments are designed to be developmentally and conceptually linked across grades so that based on assessment results, test users can describe student growth over time. In 2013, ACT employed a scaling test design to establish the vertical scales for the four ACT Aspire tests. Each student took the grade-appropriate tests and the scaling tests of the same subjects. To be operationally feasible, instead of one whole scaling test spanning all grades per subject, four separate individual scaling tests were constructed. These four separate individual scaling tests were then reconnected to recover the whole scaling test for each subject for further analysis. Interim vertical scales with desired psychometric properties were first constructed based on the reconnected whole scaling test. Each on-grade test was then linked to the interim vertical scale for each subject and each grade. To maintain the vertical scale, future forms will be horizontally equated to the base form.

## E.1 ACT Aspire Scaling Philosophy

A conceptual definition of growth is crucial in developing the vertical scale. Kolen and Brennan (2014) provided two general definitions—the domain definition and the grade-to-grade definition. Under the domain definition, growth is defined over the entire range of test content covered by the battery, or the content domain. Under the grade-to-grade definition, growth is defined over the content that is on a level appropriate for typical students at a particular grade. In designing ACT Aspire assessments, ACT did not isolate each grade's skills. ACT Aspire assessments and items were designed to elicit evidence across the construct and across the learning trajectory. As such, ACT ascribes to a domain definition of growth, where student achievement over the entire range of content is considered. This concept of growth leads naturally to the scaling test data collection design.

The scaling test design involves creating a single test with items that cover the range of content and difficulty across the domain. This test is then administered to students across all covered grades, and vertical scaling is used to place the performance of students across grades on the same scale. The next section describes in detail the scaling study used to establish the ACT Aspire score scales.

# E.2 Scaling Study

## E.2.1 Scaling Study Design

The purpose of the scaling study is to establish a vertical scale for the ACT Aspire English, mathematics, reading, and science tests. The ACT Aspire assessments include seven grade tests per subject: grades 3–8 and early high school (EHS), which is given to students in grades 9 and 10. In addition, by including grade 11 in the scaling study, the vertical scale could be extended to include the ACT, even though the ACT is not included in the ACT Aspire assessments.

The scaling test design was adopted to create the vertical scale for each subject. Under this design, each student completes two tests: an on-grade test and a scaling test with items from multiple grades. The vertical scale is defined using the scaling test, and the scores for each on-grade test are linked to the scale through the scaling test.

## E.2.2 Construction of Scaling Tests

Design of the scaling tests is a key component in creating a sound vertical scale under the scaling test design. Items from the scaling tests should cover all content that defines the vertical scale and be sensitive enough to measure growth. Since the vertical scale covers grades 3 to 11, it is ideal to construct one scaling test per subject with items from all grades and administer this single scaling test to students from grades 3 to 11.

However, to include a sufficient number of items from each content domain in the scaling test, this single test consisting of eight levels of tests (i.e., grades 3–8, 9/10, and 11) would be much too long to administer and would require students in certain grades to complete items which are significantly above or below their grade and likely achievement level. The length of the scaling test and, for example, administering high school students grade 3 items and vice versa are unlikely to result in good measurement. To create scaling tests of reasonable lengths, a single scaling test covering items from grades 3 through 11 (a whole scaling test) was broken into four separate tests in this study, each of which includes items from two or three consecutive grades with one overlapping grade (a bridge grade) between tests.

Specifically, scaling test 1 (ST1) includes items from grades 3 to 5, scaling test 2 (ST2) includes items from grades 5 to 7, scaling test 3 (ST3) includes items from grades 7 to EHS, and scaling test 4 (ST4) includes items from EHS and the ACT as shown in Figure E.1.

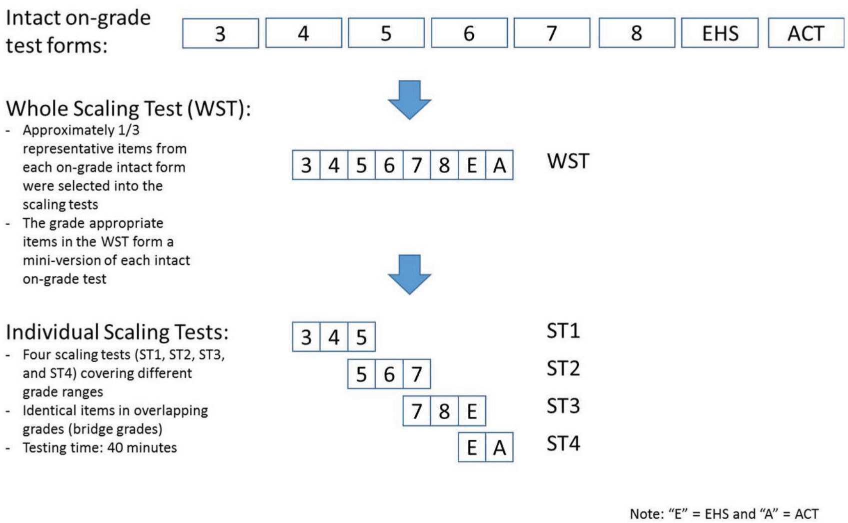



**Figure E.1. Construction of the ACT Aspire scaling tests.**

The scaling tests were designed to represent a miniature version of each on-grade test. The items chosen for the miniature version of each on-grade test were selected to be representative with respect to both content coverage and item statistics to the extent possible (approximately one third of the items on each on-grade form were used in the scaling tests). There were no common items between the scaling test and the on-grade test administered to a student.

Within each scaling test, items were grouped and sorted by grades so that lower-grade items were positioned earlier in the test than upper-grade items. Items in the bridge grade 5 were identical in ST1 and ST2. Similarly, items in the bridge grades 7 and EHS were identical in ST2 and ST3, and in ST3 and ST4, respectively. The only difference between these items in different scaling tests was that they appear at the end of the lower-level scaling test but at the beginning of the upper-level scaling test. The time limit for each scaling test was 40 minutes.

## E.2.3 Data Collection Design

The purpose of the scaling study was to set up a vertical scale spanning grades 3 to 11 and cross-sectional data collected for the study would be used for growth analysis. To minimize the impact on student growth caused by potential differences between student characteristics across grades, cross-grade samples that were similarly representative of student populations should be used. To achieve this goal, invitations were sent out to districts. If districts agreed to participate in the study, they were asked to test students from each grade. While participating districts were requested to test at least some students from every grade, not every school in a district needed to participate. ACT encouraged each district to test at least half, but preferably all its students.

Each student in grades 3–10 was asked to take four on-grade tests (i.e., English, mathematics, reading, and science) and two scaling tests of different subjects, all online. Students were not required to take the tests in one sitting or on the same day; a four-week testing window from April 22 through May 17, 2013, provided flexibility in scheduling and administering the tests. Grade 11 students took the ACT, which is all selected-response, on paper plus the ACT writing test on paper if the district opted to test writing. Administration of the ACT was standardized, and students received college-reportable ACT scores. In addition, each grade 11 student took three online 30-minute constructed-response sections (mathematics, reading, and science), two scaling tests of different subjects, and the ACT writing test (if the districts did not opt to administer the paper ACT writing test). In total, around 37,000 students from 232 schools and 23 districts in 14 states completed at least one test in the study. Demographic information for students participating in the scaling study is presented in Tables E.1–E.4.

**Table E.1. Percentages of Students Taking English Tests in the Scaling Study by Grade and Demographics**

| | Grade (N) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demographic Grouping | (4,277) | (3,825) | (4,301) | (4,683) | (4,762) | (3,609) | (2,415) | (2,258) | (2,240) |
| Gender | | | | | | | | | |
| Not Specified | 5 | 6 | 5 | 4 | 4 | 5 | 2 | 1 | 89 |
| Female | 48 | 47 | 48 | 49 | 49 | 49 | 52 | 54 | 6 |
| Male | 47 | 47 | 46 | 47 | 47 | 47 | 47 | 45 | 5 |
| Race/Ethnicity | | | | | | | | | |
| Not Specified | 33 | 34 | 31 | 26 | 30 | 30 | 39 | 35 | 93 |
| Black/African American | 27 | 27 | 29 | 27 | 24 | 22 | 29 | 28 | 3 |
| American Indian/Alaskan Native | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| White | 29 | 28 | 29 | 26 | 24 | 28 | 17 | 22 | 1 |
| Hispanic/Latino | 8 | 8 | 8 | 18 | 17 | 16 | 12 | 11 | 2 |
| Asian | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 1 |
| Native Hawaiian/ Other Pacific Islander | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Two or More Races | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 2 | |
| Geographic Region | | | | | | | | | |
| East | 35 | 40 | 36 | 31 | 30 | 40 | 25 | 24 | 24 |
| Midwest | 40 | 40 | 39 | 44 | 45 | 39 | 50 | 50 | 41 |
| Southwest | 19 | 13 | 18 | 10 | 13 | 12 | 14 | 20 | 27 |
| West | 6 | 7 | 7 | 16 | 13 | 8 | 11 | 6 | 8 |

*Note*. Zero indicates less than 0.5%. Missing values indicate no students. Percentages within a demographic grouping may not add up to 100% due to rounding.

**Table E.2. Percentages of Students Taking Mathematics Tests in the Scaling Study by Grade and Demographics**

| | Grade (N) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demographic Grouping | (4,300) | (3,830) | (4,260) | (4,577) | (4,497) | (3,746) | (2,479) | (2,528) | (1,796) |
| Gender | | | | | | | | | |
| Not Specified | 5 | 6 | 5 | 3 | 5 | 5 | 1 | 1 | 92 |
| Female | 48 | 46 | 49 | 49 | 48 | 48 | 52 | 53 | 4 |
| Male | 47 | 47 | 46 | 48 | 47 | 47 | 47 | 46 | 4 |
| Race/Ethnicity | | | | | | | | | |
| Not Specified | 33 | 34 | 31 | 26 | 31 | 29 | 38 | 38 | 94 |
| Black/African American | 27 | 28 | 29 | 27 | 23 | 24 | 29 | 25 | 3 |
| American Indian/Alaskan Native | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| White | 29 | 28 | 29 | 27 | 23 | 28 | 17 | 20 | 1 |
| Hispanic/Latino | 8 | 8 | 8 | 17 | 17 | 16 | 12 | 12 | 1 |
| Asian | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 1 |
| Native Hawaiian/ Other Pacific Islander | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Two or More Races | 1 | 0 | 1 | 1 | 3 | 1 | 0 | 2 | |
| Geographic Region | | | | | | | | | |
| East | 34 | 40 | 36 | 30 | 31 | 39 | 25 | 21 | 27 |
| Midwest | 41 | 40 | 39 | 46 | 44 | 42 | 48 | 53 | 40 |
| Southwest | 18 | 13 | 19 | 10 | 14 | 12 | 13 | 18 | 27 |
| West | 7 | 7 | 7 | 13 | 11 | 7 | 14 | 8 | 6 |

*Note.* Zero indicates less than 0.5%. Missing values indicate no students. Percentages within a demographic grouping may not add up to 100% due to rounding.

**Table E.3. Percentages of Students Taking Reading Tests in the Scaling Study by Grade and Demographics**

| | Grade (N) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demographic Grouping | (4,307) | (3,661) | (4,129) | (4,520) | (4,475) | (3,585) | (2,257) | (2,260) | (1,789) |
| Gender | | | | | | | | | |
| Not Specified | 4 | 6 | 6 | 4 | 4 | 5 | 1 | 0 | 90 |
| Female | 48 | 46 | 48 | 49 | 49 | 48 | 52 | 54 | 5 |
| Male | 48 | 48 | 46 | 47 | 47 | 47 | 46 | 46 | 4 |
| Race/Ethnicity | | | | | | | | | |
| Not Specified | 32 | 35 | 32 | 27 | 31 | 32 | 41 | 40 | 95 |
| Black/African American | 28 | 27 | 27 | 26 | 23 | 23 | 28 | 24 | 3 |
| American Indian/Alaskan Native | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| White | 28 | 28 | 30 | 27 | 24 | 27 | 17 | 21 | 1 |
| Hispanic/Latino | 9 | 8 | 8 | 17 | 16 | 16 | 10 | 10 | 1 |
| Asian | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 1 |
| Native Hawaiian/ Other Pacific Islander | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Two or More Races | 1 | 1 | 1 | 1 | 3 | 0 | 0 | 2 | |
| Geographic Region | | | | | | | | | |
| East | 36 | 41 | 37 | 32 | 30 | 40 | 26 | 23 | 26 |
| Midwest | 40 | 39 | 39 | 44 | 45 | 40 | 51 | 51 | 40 |
| Southwest | 19 | 14 | 18 | 10 | 14 | 13 | 14 | 19 | 29 |
| West | 6 | 6 | 6 | 14 | 11 | 8 | 9 | 7 | 5 |

*Note.* Zero indicates less than 0.5%. Missing values indicate no students. Percentages within a demographic grouping may not add up to 100% due to rounding.

**Table E.4. Percentages of Students Taking Science Tests in the Scaling Study by Grade and Demographics**

| | Grade (N) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Demographic Grouping | (4,214) | (3,571) | (3,903) | (4,642) | (4,756) | (3,544) | (2,167) | (2,314) | (1,717) |
| Gender | | | | | | | | | |
| Not Specified | 5 | 7 | 5 | 4 | 4 | 5 | 2 | 1 | 93 |
| Female | 48 | 46 | 48 | 49 | 49 | 49 | 51 | 54 | 4 |
| Male | 47 | 47 | 47 | 47 | 47 | 46 | 47 | 46 | 4 |
| Race/Ethnicity | | | | | | | | | |
| Not Specified | 33 | 37 | 33 | 26 | 29 | 29 | 43 | 41 | 96 |
| Black/African American | 26 | 25 | 26 | 25 | 24 | 22 | 25 | 20 | 3 |
| American Indian/Alaskan Native | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| White | 29 | 28 | 30 | 28 | 24 | 28 | 19 | 22 | 0 |
| Hispanic/Latino | 9 | 8 | 8 | 19 | 17 | 17 | 10 | 11 | 1 |
| Asian | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 1 |
| Native Hawaiian/ Other Pacific Islander | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Two or More Races | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | |
| Geographic Region | | | | | | | | | |
| East | 37 | 40 | 37 | 31 | 28 | 39 | 28 | 24 | 28 |
| Midwest | 38 | 39 | 36 | 44 | 46 | 40 | 50 | 51 | 39 |
| Southwest | 19 | 14 | 20 | 10 | 13 | 13 | 14 | 19 | 29 |
| West | 7 | 7 | 8 | 16 | 13 | 8 | 9 | 6 | 4 |

*Note.* Zero indicates less than 0.5%. Missing values indicate no students. Percentages within a demographic grouping may not add up to 100% due to rounding.

Once data were collected, analyses to create the scale were conducted separately for each subject. Students from grades 9 and 10 were combined for analyzing the EHS test. Table E.5 presents the data structure used to analyze each subject. Each row lists the student grade, and the columns list the on-grade or scaling test assigned to students. Bridge grades are listed twice, one row as "A" for students assigned to a lower-level scaling test and one row as "B" for those assigned the upper-level scaling test. The second column lists the on-grade test taken by students. The third column lists the scaling test taken by students. For example, grade 7 students (bridge grade) assigned to Group A would take the grade 7 on-grade test and the grades 5–7 scaling test (ST2). Because grades 9 and 10 were bridge grades, grade 9 students completed the EHS on-grade test plus either the lower-level scaling test (ST3) or the upper-level scaling test (ST4). Grade 10 followed a similar pattern: grade 10 students completed the EHS on-grade test plus ST3 or ST4.

In the scaling study, each student in each grade completed one scaling test and one on-grade test for the same subject. Approximately twice as many students were sampled for bridge grades (5, 7, and 9/10) compared to those from non-bridge grades to allow half of the bridge grade students to take the lower-level scaling test and half to take the upper-level one. All students in the same grade took the same on-grade test. The two groups taking lower- or upper-level scaling tests in each bridge grade were designed to be randomly equivalent. Once lists of recruited students were available, students at a bridge grade were randomly assigned to take the upper or lower level scaling test by spiraling tests across students. For example, for four students at a bridge grade in the same classroom, if the first student was assigned the lower-level scaling test, the second would be assigned the upper-, the third the lower-, and the fourth the upper-level scaling test. This spiraling pattern continued for all students in this classroom and continued into other classrooms and schools at the same grade.

**Table E.5. Data Collection Design of the Scaling Study**

| Student Grade | On-Grade | | | | | | | Scaling Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 3 | | | | | | | ST1 | | | |
| 4 | | 4 | | | | | | ST1 | | | |
| 5A | | | 5 | | | | | ST1 | | | |
| 5B | | | 5 | | | | | | ST2 | | |
| 6 | | | | 6 | | | | | ST2 | | |
| 7A | | | | | 7 | | | | ST2 | | |
| 7B | | | | | 7 | | | | | ST3 | |
| 8 | | | | | | 8 | | | | ST3 | |
| 9A | | | | | | | EHS | | | ST3 | |
| 9B | | | | | | | EHS | | | | ST4 |
| 10A | | | | | | | EHS | | | ST3 | |
| 10B | | | | | | | EHS | | | | ST4 |
| 11 | | | | | | | ACT | | | | ST4 |
| 12 | | | | | | | ACT | | | | ST4 |

*Note.* ST1 includes items from grades 3–5; ST2 includes items from grades 5–7; ST3 includes items from grades 7–EHS; and ST4 includes items from EHS and the ACT.

## E.2.4 Creation of Vertical Scales

Under the scaling test design, the vertical alignment of student performance across all grades was obtained from the scaling tests. Once the alignment was established, a scale with desirable properties (i.e., target mean, standard deviation, standard error of measurement, number of scale score points, etc.) was created. Then, the base form of each on-grade test was linked to the vertical scale. As new on-grade forms are developed, they are horizontally equated to the base form to maintain the vertical scale (see Chapter 10 for descriptions on ACT Aspire equating).

The process of establishing the ACT Aspire vertical scale can be summarized in three steps:

1. Link across the four scaling tests to establish the vertical relationship from grades 3 to 11 in a subject.
2. Create the scale with desired properties based on the linked scaling test.
3. Link each on-grade test to the vertical scale.

Detailed descriptions of these three steps are presented below.

### Step 1: Link Across the Four Scaling Tests

The goal of this step was to link the four separate scaling tests so that scores of students taking different scaling tests were put on the same scale. Note that if the whole scaling test were given to all students, this step would not be necessary. ST3 (grades 7 to EHS) was selected as the base test to conduct the linking because (a) it contained items at the top of the ACT Aspire scale, (b) two of the three other scaling tests (ST2 and ST4) could be linked to it directly, and (c) it was adjacent to ST4, which was used to link the ACT with constructed-response tests to the ACT Aspire scale.

Adjacent scaling tests were linked through random equivalent groups taking lower- and upper-level scaling tests in each bridge grade. This linking design assumed the two groups at the bridge grades, one taking the lower-level scaling test (denoted as A) and one taking the upper-level scaling test (denoted as B), were randomly equivalent.

At the data-collection stage, forms were spiraled across students within each grade in a school. Therefore, the number of students assigned to the lower-level scaling test was very close to that of students taking the upper-level test in each bridge grade of each school. However, for a variety of reasons, students assigned to a form may not have actually tested. This could lead to unbalanced numbers of students taking different scaling tests that would affect the defensibility of randomly equivalent groups. A data-cleaning rule was applied to reduce such effects and help ensure group equivalence. Specifically, if all students in the bridge grade in a school only took one level of a scaling test or if the ratio of students taking one level of the scaling test to students taking the other level was more than two, all students in that grade from that school were removed from the analysis.

To further evaluate whether the two groups were equivalent after data cleaning, raw scores from on-grade tests were compared between the two groups because they took the same on-grade test. Table E.6 presents sample size, mean, and standard deviation (SD) of on-grade test scores for the two groups in the bridge grades, as well as *p*-values of the independent-sample *t*-tests and the effect sizes between the two groups. None of the *t*-tests were statistically significant at the 0.05 level—an indication that scores for the two groups from each bridge grade did not differ significantly. Magnitudes of effect sizes were also very small (mostly within ±0.05 except for grade 9/10 English).

Instead of using randomly equivalent groups to link across scaling tests, an alternative possible design was to link through common items between adjacent scaling tests. However, since common items appeared at the end of the lower-level scaling test and at the beginning of the upper-level scaling test, context effects were a concern. Items might appear easier when they were positioned at the beginning of the test than at the end of the test. To investigate whether context effects were present, the total raw score points on the common items were compared between the two groups of students taking lower- and upper-level scaling tests. Since it was previously shown that the two groups were randomly equivalent, the average raw scores on the common items across groups should be similar if there were no context effects. If context effects did exist, statistically significant mean differences on the common items across groups would be expected. For example, it was shown that Groups 5A (grade 5 taking lower-level scaling test) and 5B (grade 5 taking upper-level scaling test) were equivalent, so if the average raw score on grade 5 items in the scaling test for 5A was different from that for 5B, context effects likely existed. Table E.7 shows descriptive statistics of raw scores on lower- and upper-level scaling tests for groups taking common items, as well as *p*-values from *t*-tests and effect sizes between scores from the two groups. Group B scored higher on the common items for all subjects and all bridge grades. Items at the beginning of the upper-level scaling test appeared to be easier than when the same items were at the end of the lower-level scaling test. The *t*-tests were statistically significant (at the 0.05 level) for grades 5 and 7 in all subjects and for grade 9/10 in mathematics and science. Context effects appeared to affect performance on the common items, which was a violation of the assumption that items should perform similarly under the common-item design. Therefore, this design was not adopted.

**Table E.6. Raw Scores of On-Grade Tests for Two Groups Taking Lower- and Upper-Level Scaling Tests**

| | | Group A | | | Group B | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Subject | Grade | N | Mean | SD | N | Mean | SD | *p*-value from *t*-test | Effect Size |
| English | 5 | 845 | 14.588 | 4.345 | 871 | 14.701 | 4.456 | 0.595 | –0.03 |
| | 7 | 889 | 19.580 | 5.898 | 928 | 19.496 | 5.820 | 0.760 | 0.01 |
| | 9/10 | 667 | 26.187 | 10.461 | 687 | 25.128 | 10.431 | 0.062 | 0.10 |
| Mathematics | 5 | 868 | 10.058 | 3.382 | 870 | 10.176 | 3.459 | 0.472 | –0.03 |
| | 7 | 863 | 15.651 | 6.453 | 882 | 15.593 | 6.239 | 0.849 | 0.01 |
| | 9/10 | 688 | 17.247 | 8.440 | 706 | 17.479 | 8.927 | 0.618 | –0.03 |
| Reading | 5 | 822 | 15.798 | 5.492 | 833 | 15.739 | 5.717 | 0.831 | 0.01 |
| | 7 | 806 | 13.166 | 5.241 | 800 | 13.340 | 5.364 | 0.511 | –0.03 |
| | 9/10 | 707 | 14.651 | 7.058 | 684 | 14.415 | 7.088 | 0.534 | 0.03 |
| Science | 5 | 727 | 18.171 | 7.132 | 721 | 18.337 | 7.104 | 0.657 | –0.02 |
| | 7 | 819 | 18.812 | 7.511 | 834 | 18.801 | 7.955 | 0.977 | 0.00 |
| | 9/10 | 634 | 14.218 | 8.082 | 648 | 14.520 | 7.772 | 0.495 | –0.04 |

**Table E.7. Raw Scores on Common Items for Two Groups Taking Lower- and Upper-Level Scaling Tests**

| | | Group A | | | Group B | | | *p*-value | Effect |
|---|---|---|---|---|---|---|---|---|---|
| Subject | Grade | N | Mean | SD | N | Mean | SD | from *t*-test | Size |
| English | 5 | 845 | 10.174 | 3.818 | 871 | 11.200 | 3.292 | < 0.0005 | -0.29 |
| | 7 | 889 | 9.529 | 3.907 | 928 | 10.335 | 3.534 | < 0.0005 | -0.22 |
| | 9/10 | 667 | 12.337 | 5.614 | 687 | 12.582 | 5.280 | 0.408 | -0.04 |
| Mathematics | 5 | 868 | 4.358 | 1.930 | 870 | 4.670 | 1.952 | 0.001 | -0.16 |
| | 7 | 863 | 3.928 | 2.299 | 882 | 4.195 | 2.296 | 0.015 | -0.12 |
| | 9/10 | 688 | 3.911 | 2.954 | 706 | 4.249 | 2.840 | 0.030 | -0.12 |
| Reading | 5 | 822 | 3.456 | 1.720 | 833 | 3.619 | 1.635 | 0.048 | -0.10 |
| | 7 | 806 | 4.227 | 2.262 | 800 | 4.591 | 2.309 | 0.001 | -0.16 |
| | 9/10 | 707 | 4.494 | 3.225 | 684 | 4.722 | 3.182 | 0.185 | -0.07 |
| Science | 5 | 727 | 3.884 | 2.129 | 721 | 4.277 | 2.080 | < 0.0005 | -0.19 |
| | 7 | 819 | 3.891 | 1.984 | 834 | 4.125 | 1.910 | 0.015 | -0.12 |
| | 9/10 | 634 | 6.412 | 4.302 | 648 | 7.110 | 4.180 | 0.003 | -0.16 |

Item response theory (IRT) was used as the statistical method to conduct the linking. This method involves putting IRT item parameter estimates from the four scaling tests on the same scale. The two-parameter logistic item response theory (2PL IRT) model was used for the dichotomously scored items, which are items scored as either right or wrong. The generalized partial credit model (GPCM) was used for polytomously scored (i.e., constructed-response) items. The 2PL IRT model contains two parameters for an item plus a parameter for student proficiency (theta). The GPCM is analogous to the 2PL IRT model but incorporates more than two score categories. All calibrations were conducted using single group analysis with the PARSCALE software (Muraki & Bock, 2003). Each of the four scaling tests was first independently calibrated. Under the randomly equivalent groups design, the mean and SD of theta scores between the two groups in the bridge grade were used to compute the scale transformation constants (see Kolen & Brennan 2014, pp. 180–182). Students with extreme theta scores (with an absolute value of 6 or more) were excluded from the calculation of means and SDs, because these theta scores were fixed by arbitrary boundaries set up in the scoring software. The obtained scale transformation slope and intercept were then applied to item parameter estimates from each independent calibration to generate the scaled item parameters for all scaling tests. Students' theta scores were then estimated from the scaled item parameters, which enabled them to be put on the same scale.

To examine and ensure the process of linking the four scaling tests did not distort the grade-to-grade growth relationships in the scaling tests, effect sizes were computed based on the predicted whole scaling test scores and compared against the effect sizes computed from individual scaling test raw scores. The predicted whole scaling test scores were IRT true score estimates on the raw score metric obtained by applying the scaled item parameter estimates of all items on the whole scaling test given the scaled theta estimates of each student obtained from the part of the whole scaling test each student actually took.

Effect size was computed as the difference between the mean scores of adjacent grades divided by the square root of the average variances for the two groups (Kolen & Brennan, 2014, p. 461). Using the reading test as an example, the grade-to-grade growth in the effect size derived from the whole scaling test scores using the 2PL IRT model, and the effect size derived from the individual scaling test raw scores were plotted in Figure E.2. For example, the grade 3 to grade 4 effect size using individual scaling test raw scores was computed using ST1 raw scores on grades 3 and 4 students. For the bridge grades, the effect size was computed between one of the randomly equivalent groups and the adjacent grade taking the same scaling test. For example, the effect size between grades 4 and 5 was computed on ST1 raw scores between grades 4 and 5A students; the effect size between grades 5 and 6 was computed on ST2 raw scores between grades 5B and 6 students. Since Groups 5A and 5B were shown to be equivalent, either group could be treated as a representative of the Grade 5 student sample. The effect size between grades 9 and 10 was the average of effect sizes for 9A versus 10A and 9B versus 10B.

The overall growth pattern was very similar between the two sets of effect sizes, which indicated that the linking process did not distort the original grade-to-grade relationship. The magnitude of growth tended to decrease as the grade increased, with growth from grades 3 to 5 among the largest. There was zero to slightly negative growth observed between grades 5 and 6 for the reading test.

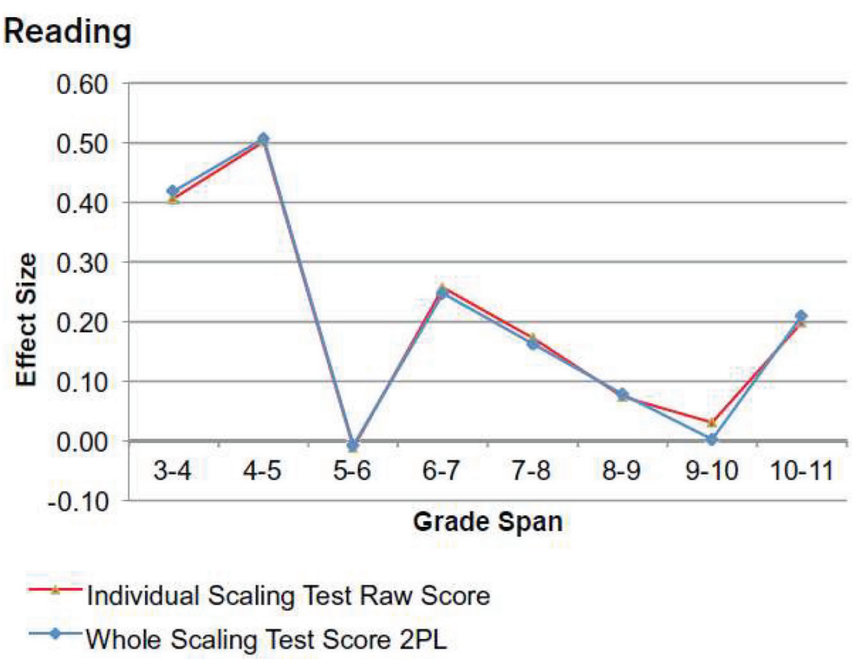



**Figure E.2. Effect sizes on individual scaling test raw score metric and whole scaling test raw score metric derived from the 2PL IRT model.**

## Step 2: Create the Vertical Scale Based on the Linked Scaling Tests

### *Generate the Projected Whole Scaling Test Raw Scores*

After Step 1 was completed, IRT item parameter estimates for all four scaling tests were placed on the same scale. Students' theta scores were also on the same scale when estimated from the scaled item parameter estimates. Based on the scaled item parameter and theta estimates, students' IRT true score estimates on the whole scaling test, which were on the raw score metric, were estimated from the IRT test characteristic curve of the whole scaling test.

### *Create an Interim Scale with Constant Conditional Standard Error of Measurement (CSEM)*

The conditional standard error of measurement (CSEM) of the raw scores on a test is typically an inverted U shape with much smaller CSEM values at the two ends. To stabilize the CSEM along the score scale, raw scores on the whole scaling test were nonlinearly transformed to an interim score scale using the arcsine transformation (e.g., see Kolen & Brennan, 2014, p. 405). Although this stabilization was applied to the scaling test to obtain a constant CSEM property for the ACT Aspire scale, after the on-grade tests were linked to the whole scaling test, there was no guarantee that the constant CSEM property would be maintained on the on-grade tests. Empirical results indicated that applying the arcsine transformation did help to stabilize the scale score CSEM of the on-grade test after it was linked to the whole scaling test.

To compute the CSEM, an extended Lord-Wingersky recursive algorithm (Hanson, 1994; Wang, Kolen, & Harris 2000, p. 219; Kolen & Brennan, 2014, p. 199) was adopted to obtain the expected distribution on the interim scale score for each student based on that student's theta score. The SD of the expected score distribution was the CSEM of the interim score scale for that student. Weights were used to equalize the contribution of students from different grades to the CSEM calculation because sample sizes varied across grades, particularly for the bridge grades where the data-collection design resulted in larger samples of students compared to other grades (e.g., see sample sizes listed in Tables E.8–E.11).

### *Linear Transformation of the Interim Scale to the Final Scale*

The interim scale scores, with the property of constant CSEMs, were then linearly transformed to the ACT Aspire scale. Since linear transformation does not change the relative magnitude of the CSEMs, the constant CSEM property was carried over to the final scale. The linear transformation was selected so that the standard error of measurement on the whole scaling test was about 1.8 scale score points, and the mean was set to an arbitrary value to anchor the scale.

### Step 3: Link the On-Grade Test to the Vertical Scale

The last step in the vertical linking process was to link each of the on-grade English, mathematics, reading, and science tests to the vertical scale established using the whole scaling test in each subject. A single-group linking design was adopted, since the same group of students took both the on-grade test and the scaling test in the same subject.

The IRT observed-score linking method (Kolen & Brennan, 2014) was used to create the link. First, each on-grade test was calibrated independently. Second, item parameter estimates from the on-grade test were transformed to the whole scaling test scale by matching the mean and standard deviation of theta scores estimated from each on-grade test to those of theta scores estimated from the scaled item-parameter estimates of the scaling tests. Third, the estimated distribution of number-correct scores (using scaled item parameter estimates) on the on-grade form was linked to that of the whole scaling test. The IRT-observed score linking yielded the raw-to-scale conversion for each on-grade test. The scale scores were rounded, truncated, and shifted to some desired score ranges to provide the final reportable scale scores.

## E.3 Evaluation of the Vertical Scales

Once the scale was created and students' scale scores were generated, the following analyses were conducted to evaluate the scales:

1. *Check whether the scale maintains the on-the-same-scale property.* When multiple grades of students took the same scaling test, their scores on that scaling test were already on the same scale. The entire scaling process for ACT Aspire involved multiple steps, including connecting individual scaling tests and linking the on-grade test to the whole scaling test. Therefore, it was important to verify that ACT Aspire scale scores obtained from on-grade tests could maintain the vertical relationships obtained from the scaling test. This property is referred to as the on-the-same-scale property. To evaluate this property, raw scores on each of the four scaling tests were used as a reference to define the observed relationships across grades. If the on-the-same-scale property was maintained, students who had the same raw scores on the scaling test should have similar scale scores derived from the on-grade test, even though their scale scores are from on-grade tests at different grades.
2. *Evaluate the constant CSEM property.* As mentioned above, the CSEM stabilization process was applied to the scale defined by the scaling tests. To evaluate whether this property was maintained for the on-grade tests, CSEM curves for each on-grade test were plotted and examined.
3. *Evaluate the growth pattern.* The growth patterns derived from ACT Aspire scale scores were examined and compared against the growth patterns derived from the raw scores on the scaling tests.

# E.4 Results

## E.4.1 Scaling Test Raw Scores

Tables E.8–E.11 present the means and SDs of raw scores on individual scaling tests and the means and SDs of raw scores on the grade-specific items in each test. For example, the grade 3 students' average raw score was 22.525 for the English scaling test (ST1), and when items were grouped by grades, the average score was 7.313 on all grade 3 items, 7.481 on all grade 4 items, and 7.731 on all grade 5 items. The average scores on items from different grades (i.e., across the columns) were not directly comparable since the number of items was different across grades. Similarly, average scaling test raw scores were only comparable among groups who took the same scaling test since the numbers of score points and most of the items were different across the four scaling tests.

Within each scaling test, summarizing the average total raw score on the scaling test by grade provides diagnostic information about where growth occurs. For example, a slightly negative growth occurred between grade 5 students (5B) and grade 6 students on ST2 in reading. Reviewing the means on items grouped by grade revealed that reverse growth occurred on the grade 6 items for reading. Another example of negative growth was on ST4 in reading between Groups 9B and 10B. Group 10B performed worse on both the EHS and the ACT items.

Context effects were also observed in Tables E.8–E.11 between the bridge grade students (Groups A and B) since within a single grade the common item mean scores were always higher in Group B (where common items were given at the beginning of the test) than Group A (where common items are given at the end of the test). This is true for all subjects and all bridge grades. As explained earlier, this was one reason why the common-item linking design was not used to develop the vertical scale.

The SDs of raw scores tended to increase as grade increased within the same scaling test. In other words, group variability increased as grade increased.

## E.4.2 Evaluating On-the-Same-Scale Property

Figure E.3 presents plots of the average scale scores per grade against the scaling test raw scores by scaling test. On average, students with the same scaling test raw score had similar scale scores, regardless of which on-grade tests they have taken. These results are consistent with an interpretation of scores of on-grade tests as being on the same vertical scale.

**Table E.8. Mean and Standard Deviation of Raw Scores on English Scaling Test (ST) by Grade-Specific Items**

| Scaling Test (Score Range) | Grade | N | Mean (SD) of ST | Mean (SD) of Grade Specific Items (Score Range) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | G3 (0–16) | G4 (0–17) | G5 (0–17) | G6 (0–16) | G7 (0–17) | G8 (0–16) | G_EHS (0–25) | G_ACT (0–45) |
| ST1 (0–50) | 3 | 1,810 | 22.525 (7.975) | 7.313 (2.542) | 7.481 (3.308) | 7.731 (3.499) | | | | | |
| | 4 | 1,617 | 26.078 (8.320) | 8.208 (2.585) | 8.730 (3.347) | 9.140 (3.689) | | | | | |
| | 5A | 845 | 29.060 (8.631) | 9.058 (2.713) | 9.828 (3.380) | 10.174 (3.818) | | | | | |
| ST2 (0–50) | 5B | 871 | 28.021 (8.704) | | | 11.200 (3.292) | 8.503 (2.998) | 8.318 (3.582) | | | |
| | 6 | 1,824 | 28.548 (9.528) | | | 11.386 (3.604) | 8.490 (3.189) | 8.672 (3.834) | | | |
| | 7A | 889 | 30.670 (9.678) | | | 12.048 (3.496) | 9.093 (3.280) | 9.529 (3.907) | | | |
| ST3 (0–58) | 7B | 928 | 29.763 (10.335) | | | | | 10.335 (3.534) | 8.672 (3.524) | 10.755 (4.514) | |
| | 8 | 1,436 | 31.769 (11.059) | | | | | 10.818 (3.683) | 9.171 (3.677) | 11.781 (4.807) | |
| | 9A | 343 | 32.402 (12.237) | | | | | 11.117 (3.975) | 9.172 (4.042) | 12.114 (5.228) | |
| | 10A | 324 | 32.710 (13.787) | | | | | 10.843 (4.267) | 9.293 (4.410) | 12.574 (5.995) | |
| ST4 (0–70) | 9B | 368 | 29.481 (12.552) | | | | | | | 12.332 (5.122) | 17.149 (8.281) |
| | 10B | 319 | 31.367 (14.036) | | | | | | | 12.871 (5.450) | 18.495 (9.288) |
| | 11 | 760 | 32.925 (13.797) | | | | | | | 13.943 (5.206) | 18.982 (9.356) |

**Table E.9. Mean and Standard Deviation of Raw Scores on Mathematics Scaling Test (ST) by Grade-Specific Items**

| Scaling Test (Score Range) | Grade | N | Mean (SD) of ST | Mean (SD) of Grade Specific Items (Score Range) G3 (0–12) | G4 (0–12) | G5 (0–13) | G6 (0–11) | G7 (0–13) | G8 (0–7) | G_EHS (0–17) | G_ACT (0–21) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ST1 (0–37) | 3 | 1,793 | 9.090 (3.573) | 3.732 (1.944) | 2.697 (1.472) | 2.661 (1.503) | | | | | |
| | 4 | 1,624 | 11.580 (4.360) | 4.573 (2.029) | 3.345 (1.841) | 3.662 (1.743) | | | | | |
| | 5A | 868 | 13.778 (5.169) | 5.315 (2.133) | 4.105 (2.212) | 4.358 (1.930) | | | | | |
| ST2 (0–37) | 5B | 870 | 9.924 (3.434) | | | 4.670 (1.952) | 2.600 (1.237) | 2.654 (1.501) | | | |
| | 6 | 1,751 | 10.817 (4.216) | | | 4.812 (2.047) | 2.939 (1.428) | 3.065 (1.752) | | | |
| | 7A | 863 | 12.818 (5.17) | | | 5.395 (2.129) | 3.495 (1.693) | 3.928 (2.299) | | | |
| ST3 (0–37) | 7B | 882 | 9.347 (4.689) | | | | | 4.195 (2.296) | 2.407 (1.508) | 2.745 (1.942) | |
| | 8 | 1,451 | 10.580 (5.289) | | | | | 4.504 (2.369) | 2.682 (1.505) | 3.394 (2.375) | |
| | 9A | 381 | 11.213 (6.218) | | | | | 4.559 (2.704) | 2.877 (1.679) | 3.777 (2.719) | |
| | 10A | 307 | 12.160 (7.023) | | | | | 5.156 (2.836) | 2.925 (1.745) | 4.078 (3.219) | |
| ST4 (0–38) | 9B | 376 | 10.580 (5.691) | | | | | | | 4.133 (2.632) | 6.447 (3.427) |
| | 10B | 330 | 11.361 (6.926) | | | | | | | 4.382 (3.060) | 6.979 (4.269) |
| | 11 | 669 | 12.765 (6.632) | | | | | | | 5.139 (3.041) | 7.626 (4.087) |

**Table E.10. Mean and Standard Deviation of Raw Scores on Reading Scaling Test (ST) by Grade-Specific Items**

| Scaling Test (Score Range) | Grade | N | Mean (SD) of ST | Mean (SD) of Grade Specific Items (Score Range) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | G3 (0–8) | G4 (0–8) | G5 (0–7) | G6 (0–9) | G7 (0–10) | G8 (0–5) | G_EHS (0–13) | G_ACT (0–18) |
| ST1 (0–23) | 3 | 1,769 | 8.077 (4.054) | 3.003 (1.686) | 2.757 (1.879) | 2.317 (1.451) | | | | | |
| | 4 | 1,569 | 9.811 (4.467) | 3.516 (1.755) | 3.587 (2.040) | 2.709 (1.573) | | | | | |
| | 5A | 822 | 12.102 (4.67) | 4.153 (1.710) | 4.493 (2.154) | 3.456 (1.720) | | | | | |
| ST2 (0–26) | 5B | 833 | 12.552 (4.903) | | | 3.619 (1.635) | 5.261 (2.322) | 3.672 (2.036) | | | |
| | 6 | 1,759 | 12.495 (5.357) | | | 3.624 (1.695) | 5.077 (2.422) | 3.794 (2.179) | | | |
| | 7A | 806 | 13.878 (5.384) | | | 3.970 (1.685) | 5.681 (2.388) | 4.227 (2.262) | | | |
| ST3 (0–28) | 7B | 800 | 10.824 (5.344) | | | | | 4.591 (2.309) | 2.644 (1.502) | 3.589 (2.491) | |
| | 8 | 1,321 | 11.775 (5.687) | | | | | 4.861 (2.359) | 2.864 (1.597) | 4.050 (2.697) | |
| | 9A | 386 | 12.212 (6.105) | | | | | 4.982 (2.375) | 2.876 (1.621) | 4.355 (2.988) | |
| | 10A | 321 | 12.879 (7.243) | | | | | 5.202 (2.807) | 3.016 (1.769) | 4.660 (3.487) | |
| ST4 (0–31) | 9B | 369 | 11.756 (6.02) | | | | | | | 4.772 (3.094) | 6.984 (3.529) |
| | 10B | 315 | 11.514 (6.701) | | | | | | | 4.663 (3.287) | 6.851 (3.932) |
| | 11 | 707 | 12.795 (6.181) | | | | | | | 5.413 (3.059) | 7.382 (3.775) |

**Table E.11. Mean and Standard Deviation of Raw Scores on Science Scaling Test (ST) by Grade-Specific Items**

| Scaling Test (Score Range) | Grade | N | Mean (SD) of ST | Mean (SD) of Grade Specific Items (Score Range) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | G3 (0–6) | G4 (0–16) | G5 (0–9) | G6 (0–14) | G7 (0–8) | G8 (0–11) | G_EHS (0–17) | G_ACT (0–22) |
| ST1 (0–31) | 3 | 1,806 | 12.108 (5.049) | 3.538 (1.515) | 6.095 (2.909) | 2.475 (1.699) | | | | | |
| | 4 | 1,551 | 14.453 (5.466) | 3.983 (1.434) | 7.362 (3.168) | 3.108 (1.873) | | | | | |
| | 5A | 727 | 16.993 (5.945) | 4.415 (1.286) | 8.693 (3.484) | 3.884 (2.129) | | | | | |
| ST2 (0–31) | 5B | 721 | 15.434 (6.267) | | | 4.277 (2.080) | 7.712 (3.247) | 3.445 (1.852) | | | |
| | 6 | 1,514 | 15.687 (6.789) | | | 4.327 (2.236) | 7.814 (3.448) | 3.546 (1.984) | | | |
| | 7A | 819 | 17.098 (6.836) | | | 4.750 (2.245) | 8.457 (3.440) | 3.891 (1.984) | | | |
| ST3 (0–36) | 7B | 834 | 14.138 (6.306) | | | | | 4.125 (1.910) | 4.788 (2.266) | 5.225 (3.302) | |
| | 8 | 1,426 | 15.243 (6.993) | | | | | 4.391 (1.946) | 5.100 (2.400) | 5.752 (3.749) | |
| | 9A | 336 | 16.202 (8.015) | | | | | 4.464 (2.141) | 5.390 (2.728) | 6.348 (4.195) | |
| | 10A | 298 | 16.319 (8.281) | | | | | 4.470 (2.181) | 5.366 (2.707) | 6.483 (4.425) | |
| ST4 (0–39) | 9B | 328 | 14.137 (6.547) | | | | | | | 6.747 (3.832) | 7.390 (3.517) |
| | 10B | 320 | 15.272 (7.795) | | | | | | | 7.481 (4.484) | 7.791 (4.066) |
| | 11 | 685 | 15.540 (7.576) | | | | | | | 7.672 (4.232) | 7.869 (4.138) |

### A. English

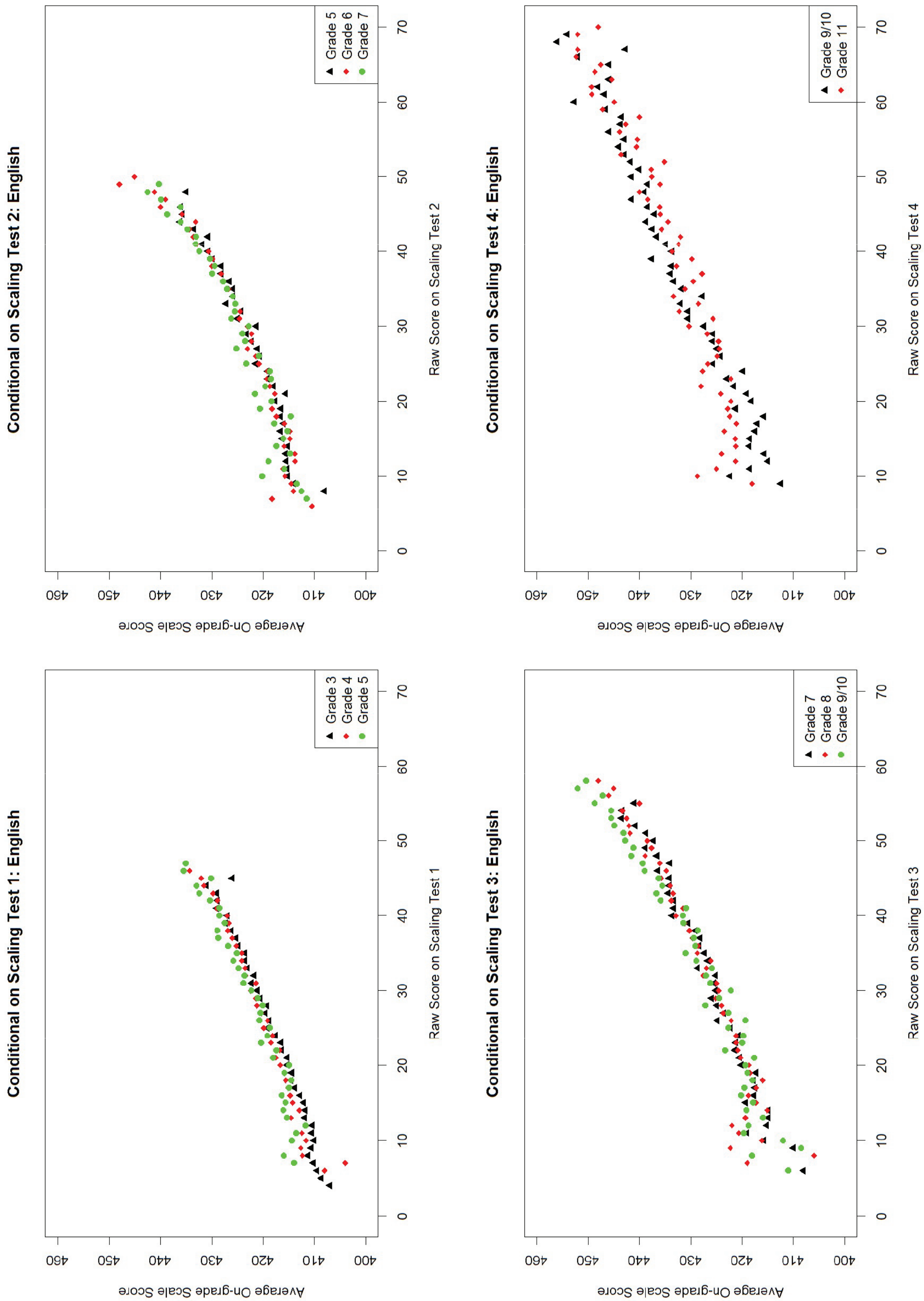



**Figure E.3. Scatterplots of average scale scores against scaling test raw scores by grade.**

## B. Mathematics

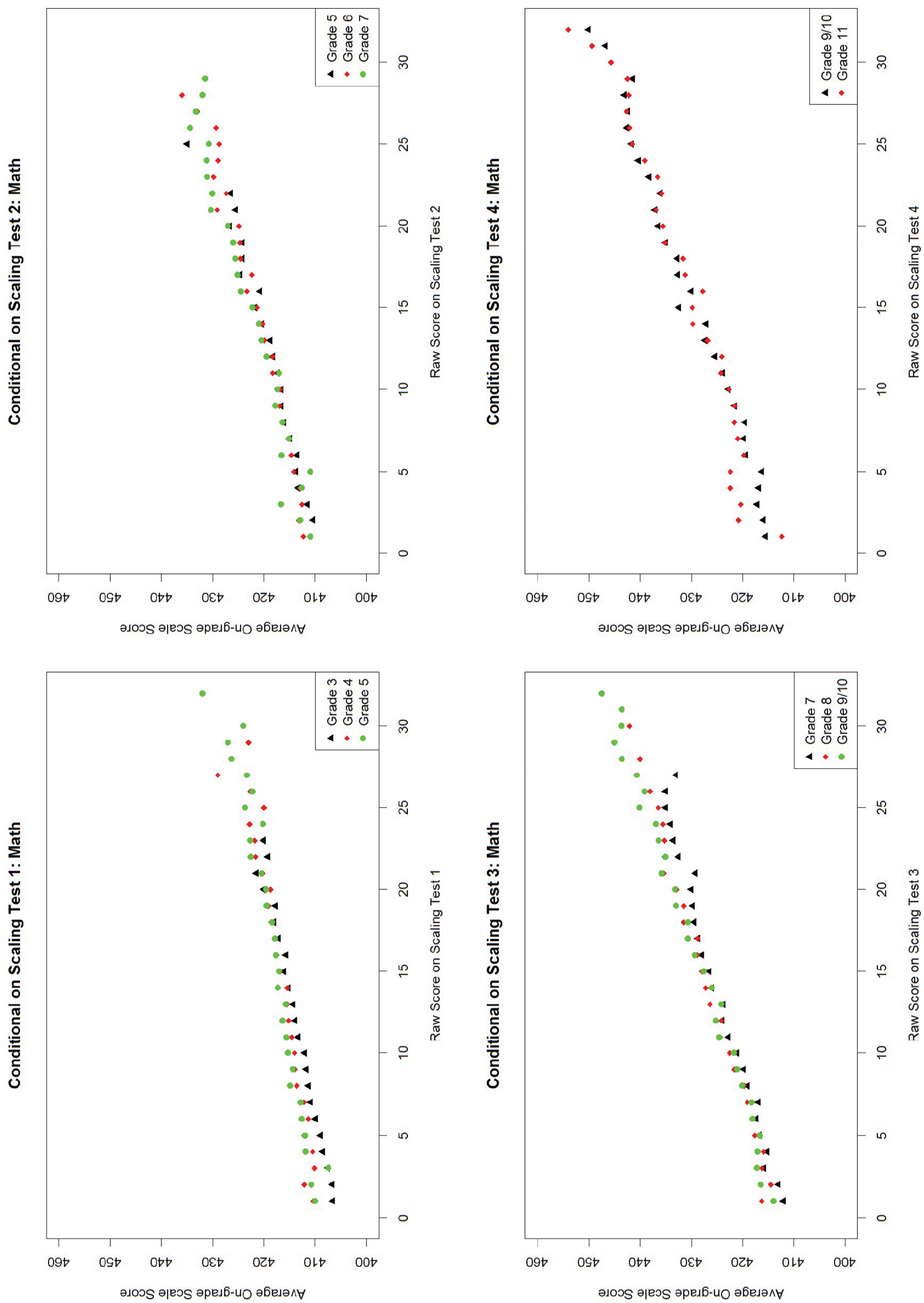



**Figure E.3. Scatterplots of average scale scores against scaling test raw scores by grade—continued.**

## C. Reading

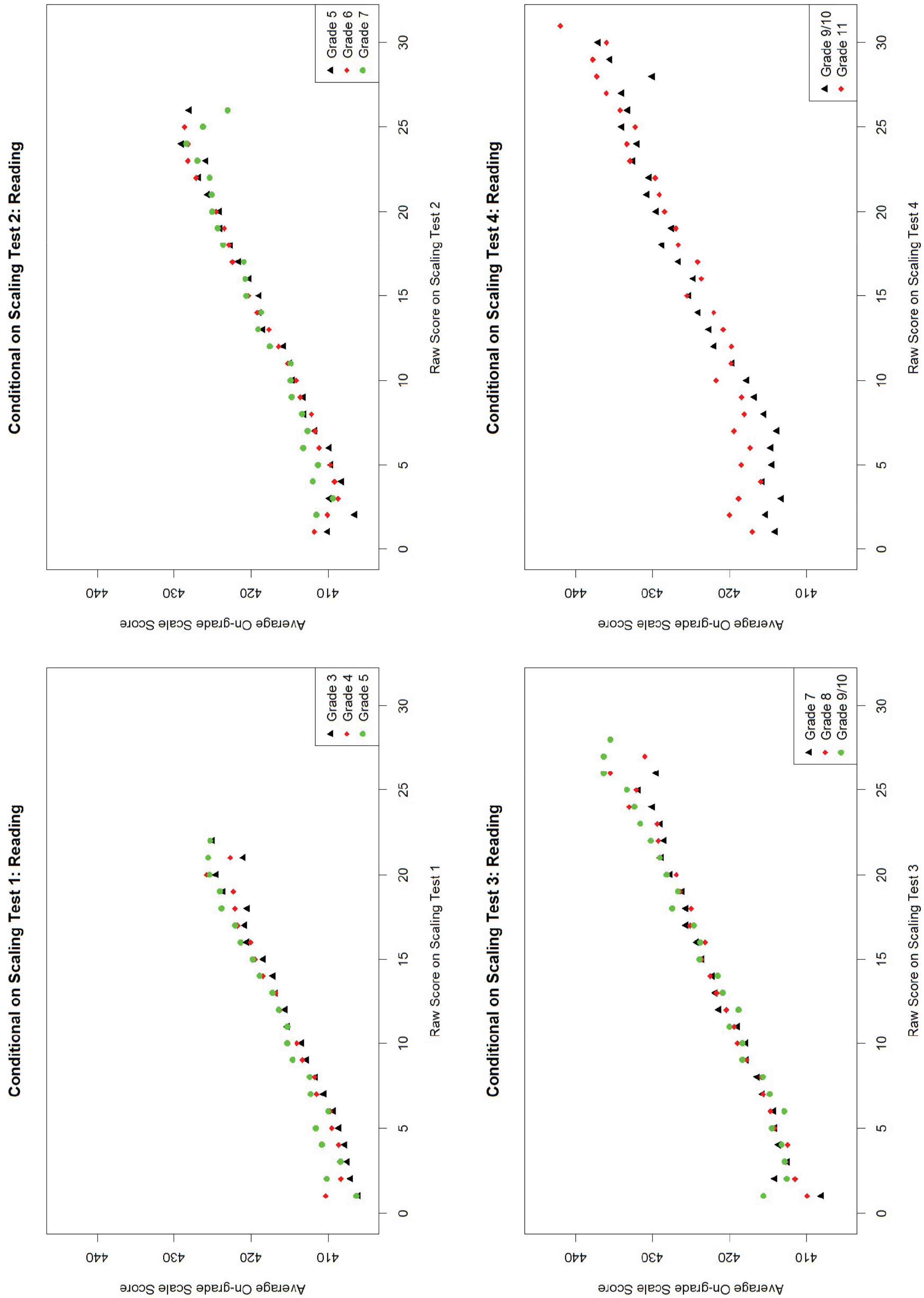



**Figure E.3. Scatterplots of average scale scores against scaling test raw scores by grade—continued.**

## D. Science

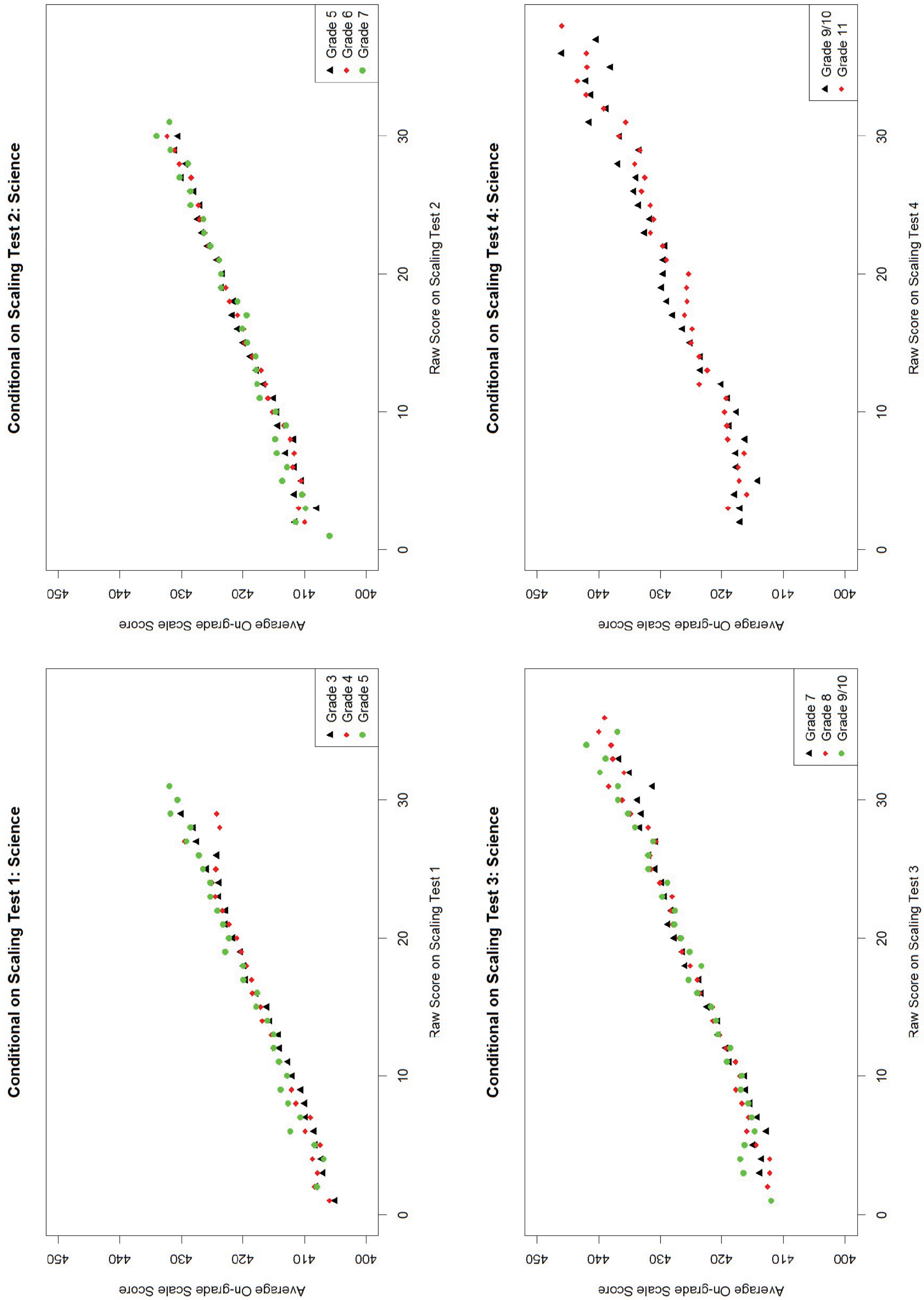



**Figure E.3. Scatterplots of average scale scores against scaling test raw scores by grade—continued.**

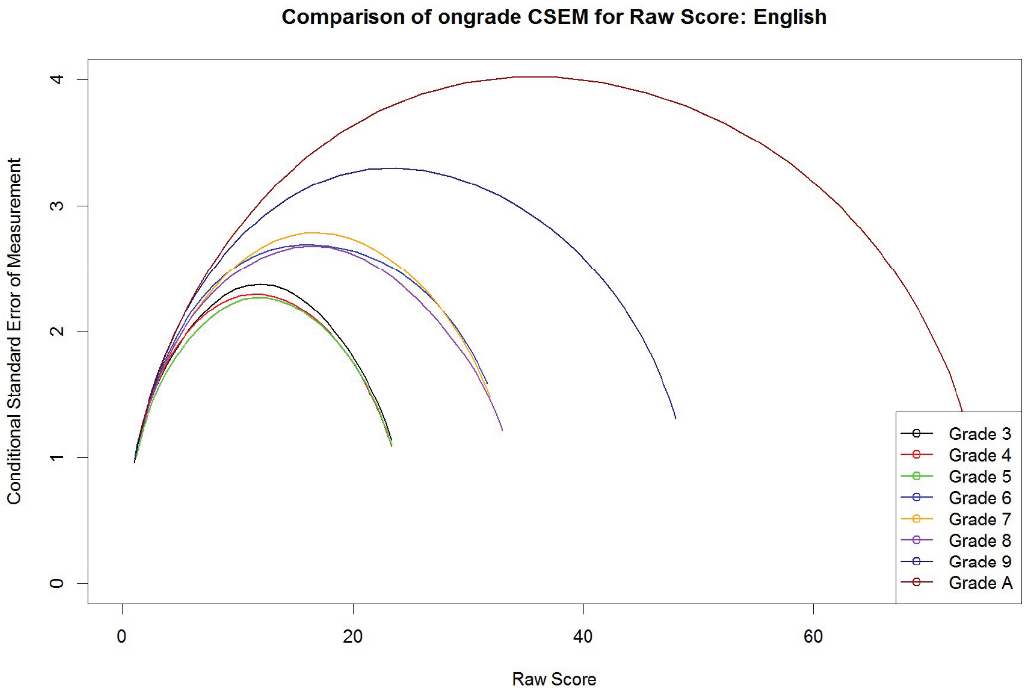
## E.4.3 Evaluating Constant Conditional Standard Error of Measurement Property

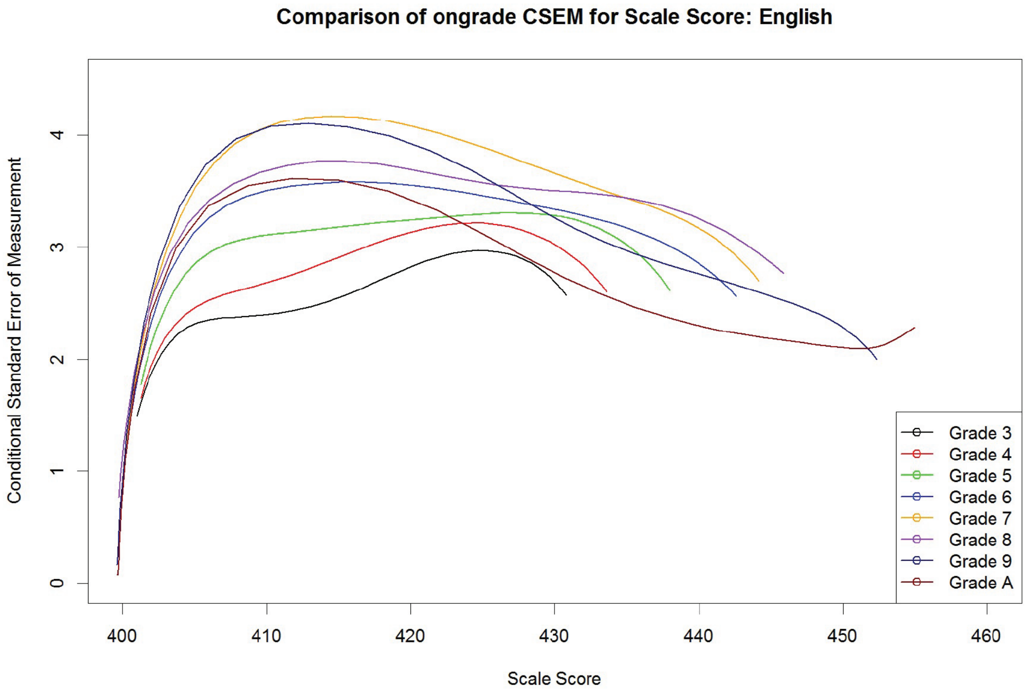
The CSEMs of raw scores and scale scores for English, mathematics, reading, and science were plotted in Figure E.4. Each figure represents the CSEMs for raw or scale scores on one ACT Aspire subject, and each curve in the figure represents a grade.

The ACT Aspire score scales begin at 400 and have different maximum values (up to 460) depending on the grade and subject area. For most grades and subjects, the scale score CSEM curves were relatively flat along the scale range, especially when compared to the raw score CSEMs, which showed a typical inverted U shape.

In Figure E.4, for most ACT Aspire scale score points, CSEMs were within a range of two scale score points. The CSEMs dropped dramatically when scale scores were low. Also, the CSEMs never appeared higher than roughly 4 scale score points. While these CSEMs were not perfectly flat, they were reasonably constant. For example, the second graph in Figure E.4 presented CSEMs for English, and the CSEMs for most of the scale score points were between 2 and 4 scale score points across all grades. Within each grade for all subjects, scale score CSEMs were generally within 1 score point for most of the scale score points. For example, the grade 4 English CSEM for scale scores fluctuated between 2 and 3 across most of the scale score points excluding the bottom few scale score points.

## A. English

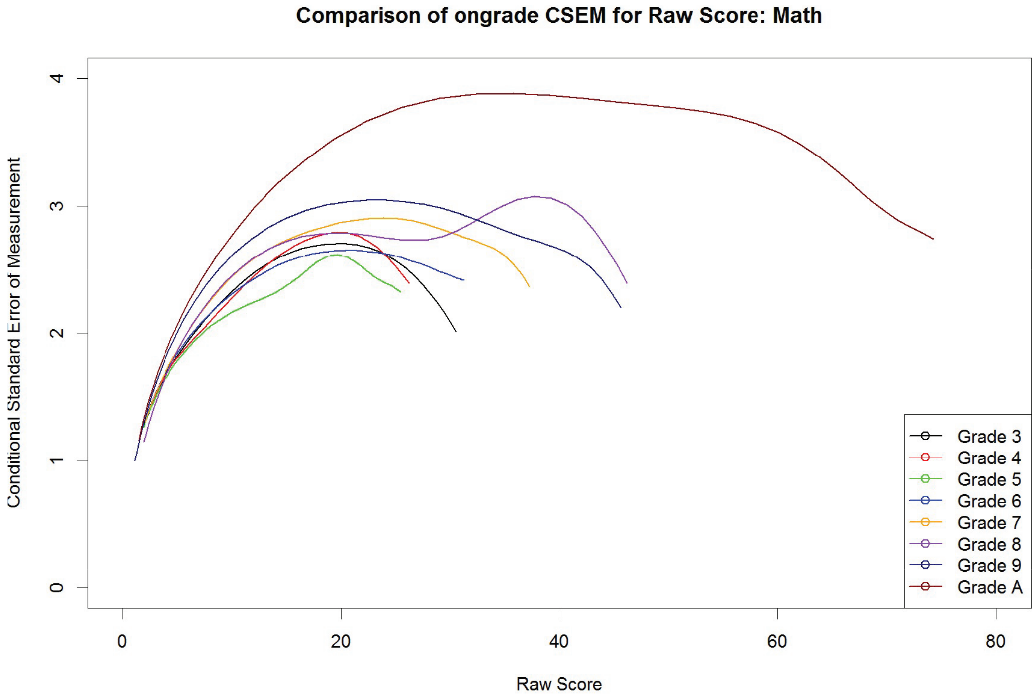


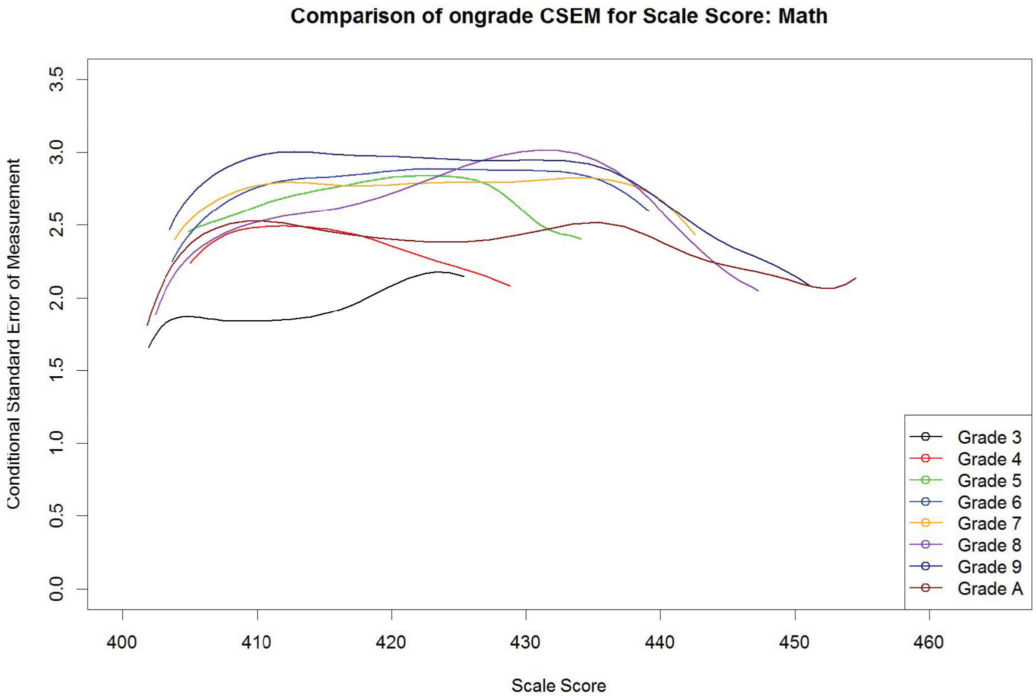




*Note*. Grade A meant those who took the ACT tests.

**Figure E.4. Conditional standard error of measurement on raw and scale score scales.**

## B. Mathematics

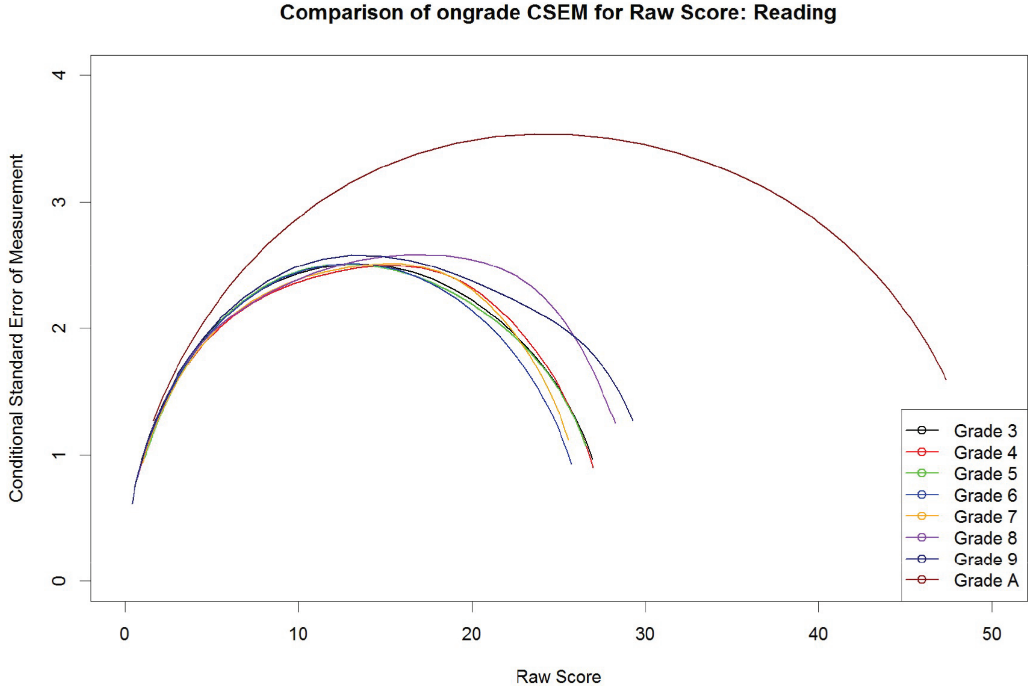


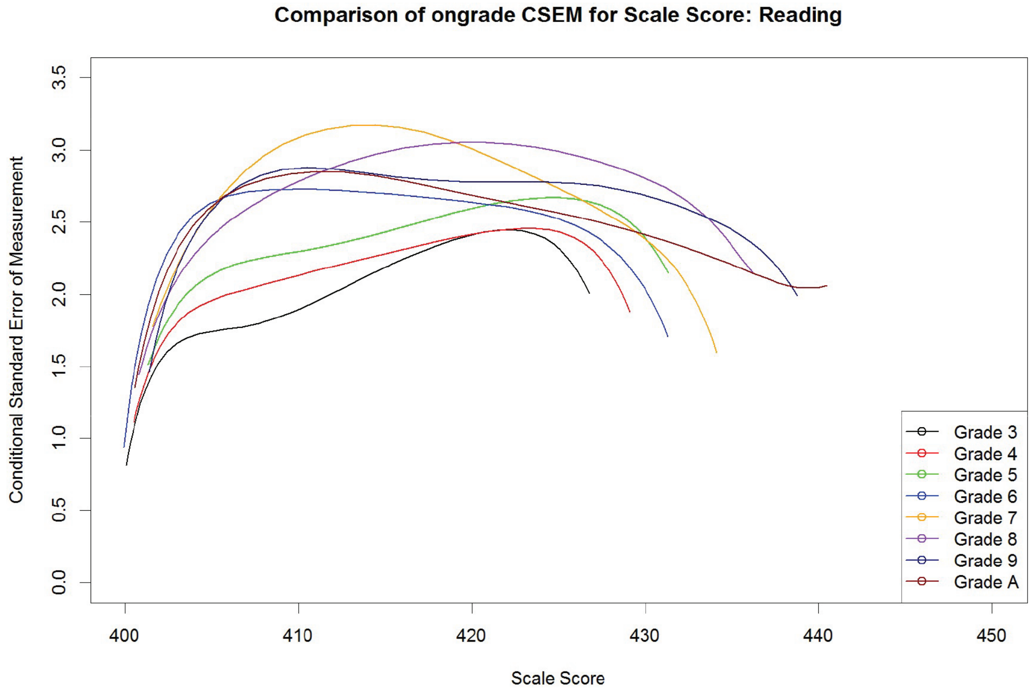




*Note.* Grade A meant those who took the ACT tests.

**Figure E.4. Conditional standard error of measurement on raw and scale score scales—continued.**

### C. Reading

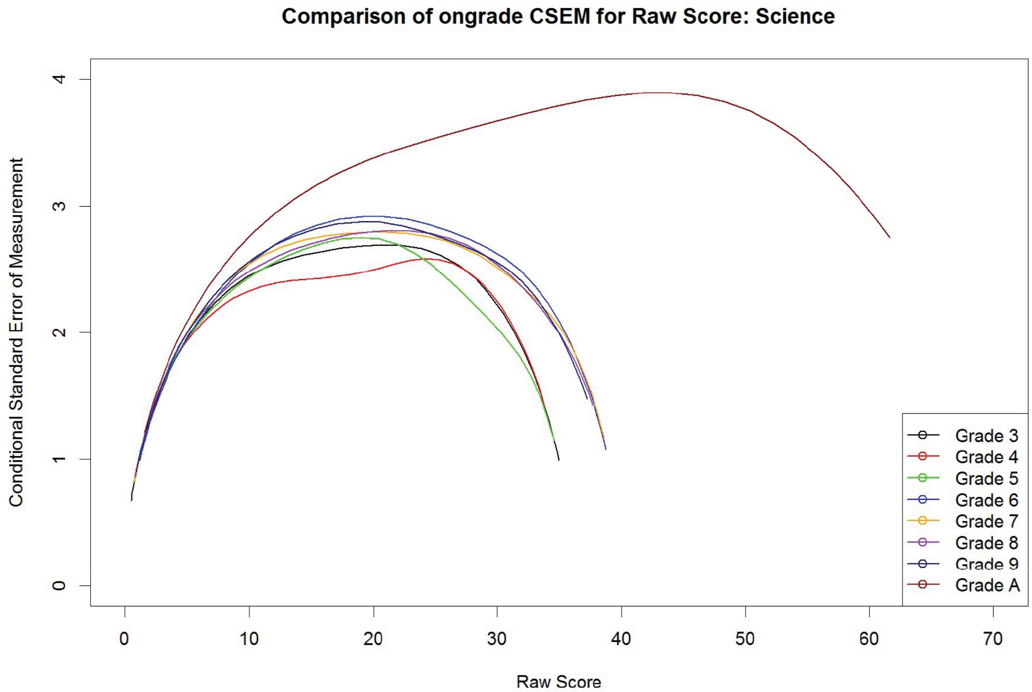


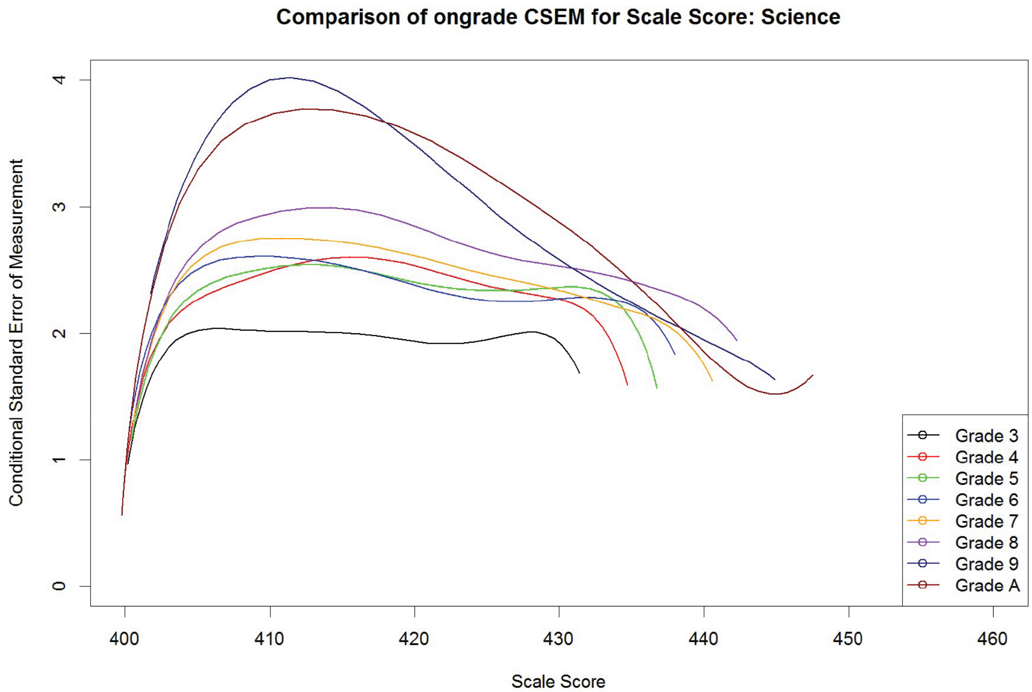




*Note.* Grade A meant those who took the ACT tests.

**Figure E.4. Conditional standard error of measurement on raw and scale score scales—continued.**

## D. Science




*Note.* Grade A meant those who took the ACT tests.

**Figure E.4. Conditional standard error of measurement on raw and scale score scales—continued.**

# E.4.4 Growth Patterns

Effect sizes that were derived from comparing different grades for three types of scores were computed and compared. Figure E.5 displays three sets of effect sizes, one derived from the individual scaling test raw scores, one from the projected whole scaling test scores, and one from the final ACT Aspire scale scores on the on-grade test.

Effect sizes that were derived from individual scaling test raw scores were computed between two groups taking the same scaling test as described in the section Creation of Vertical Scales—Step 1: Link Across the Four Scaling Tests.

In general, the three sets of effect sizes for lower grades (3–8) were very similar. The patterns diverged in some cases for upper grades. One reason might be that students in grades 9 and 10 were combined during the scaling analysis. Also, there were two sources of growth from grade 9 to grade 10: between 9A and 10A students who took ST3 and between 9B and 10B students who took ST4. The effect size that was computed using the scaling test raw scores was the average of both sources. If the growth patterns were different from 9A to 10A than from 9B to 10B, this might lead to different effect sizes between grades 9 and 10 when combining Groups A and B.

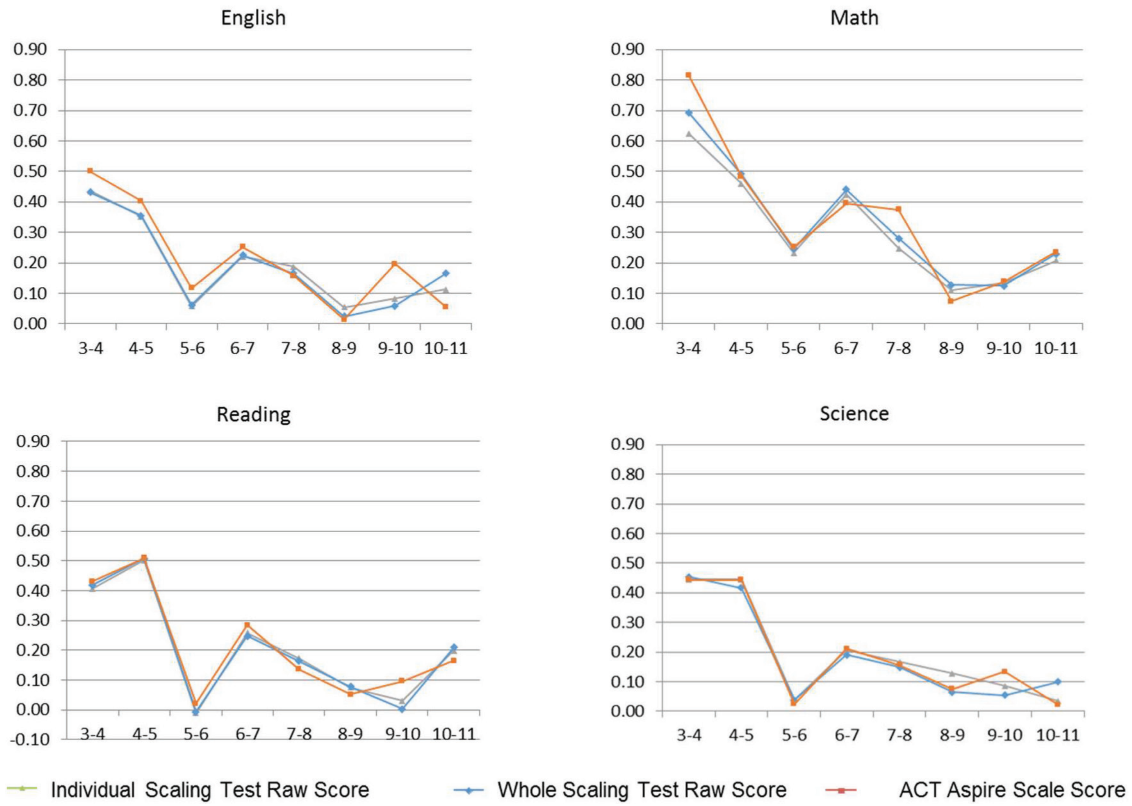



**Figure E.5. Effect sizes on individual scaling test raw score scale, whole scaling test raw score scale, and ACT Aspire on-grade test score scale.**

Basic descriptive statistics of the final scale scores for all students in the scaling study are presented in Tables E.12–E.15 for English, mathematics, reading, and science, respectively. Note that the *n*-counts in these tables were larger than the groups used for the scaling analysis, where only students who took both scaling tests and on-grade tests were included. Since they were not longitudinal data and samples may not be representative in each grade, the decreasing means observed for certain subjects as grades increased may be attributable to the characteristic of the sample rather than a characteristic of the scale. Future results from operational administrations with larger samples of relatively motivated students taking ACT Aspire over multiple years will provide more robust estimates of longitudinal growth on the ACT Aspire score scale.

**Table E.12. English Scale Score Descriptive Statistics Based on Scaling Study by Grade**

| Grade | N | Mean | SD | Min | P10 | P25 | P50 | P75 | P90 | P95 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4,277 | 416.50 | 6.14 | 403 | 409 | 412 | 416 | 421 | 424 | 428 | 435 |
| 4 | 3,825 | 419.65 | 6.23 | 402 | 411 | 415 | 420 | 423 | 428 | 430 | 438 |
| 5 | 4,301 | 421.98 | 7.04 | 403 | 413 | 417 | 421 | 427 | 431 | 435 | 442 |
| 6 | 4,683 | 422.56 | 8.09 | 400 | 412 | 416 | 423 | 428 | 433 | 437 | 448 |
| 7 | 4,762 | 424.84 | 8.56 | 400 | 413 | 419 | 425 | 430 | 436 | 439 | 450 |
| 8 | 3,609 | 426.38 | 8.94 | 401 | 415 | 421 | 426 | 433 | 438 | 442 | 452 |
| 9 | 2,415 | 425.48 | 10.76 | 400 | 413 | 417 | 424 | 433 | 440 | 445 | 456 |
| 10 | 2,258 | 429.07 | 11.59 | 400 | 414 | 419 | 429 | 439 | 445 | 447 | 456 |
| 11 | 2,240 | 429.15 | 11.64 | 400 | 414 | 420 | 429 | 438 | 445 | 448 | 460 |

**Table E.13. Mathematics Scale Score Descriptive Statistics Based on Scaling Study by Grade**

| Grade | N | Mean | SD | Min | P10 | P25 | P50 | P75 | P90 | P95 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4,300 | 411.75 | 3.69 | 400 | 407 | 409 | 412 | 414 | 417 | 418 | 426 |
| 4 | 3,830 | 414.75 | 3.81 | 403 | 410 | 413 | 415 | 417 | 420 | 421 | 429 |
| 5 | 4,260 | 416.78 | 4.43 | 404 | 412 | 414 | 417 | 419 | 422 | 424 | 435 |
| 6 | 4,577 | 418.15 | 5.72 | 402 | 412 | 414 | 418 | 421 | 426 | 429 | 441 |
| 7 | 4,497 | 419.83 | 6.42 | 402 | 413 | 415 | 419 | 424 | 429 | 431 | 442 |
| 8 | 3,746 | 422.48 | 7.30 | 403 | 413 | 417 | 422 | 427 | 432 | 436 | 448 |
| 9 | 2,479 | 422.82 | 8.05 | 406 | 414 | 417 | 422 | 428 | 434 | 438 | 449 |
| 10 | 2,528 | 425.15 | 9.10 | 406 | 414 | 418 | 424 | 432 | 438 | 441 | 450 |
| 11 | 1,796 | 427.34 | 9.38 | 407 | 417 | 420 | 426 | 433 | 441 | 445 | 457 |

**Table E.14. Reading Scale Score Descriptive Statistics Based on Scaling Study by Grade**

| Grade | N | Mean | SD | Min | P10 | P25 | P50 | P75 | P90 | P95 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4,307 | 411.56 | 5.27 | 401 | 406 | 407 | 411 | 415 | 419 | 422 | 429 |
| 4 | 3,661 | 414.02 | 5.66 | 401 | 407 | 410 | 414 | 418 | 423 | 424 | 431 |
| 5 | 4,129 | 416.20 | 6.23 | 401 | 408 | 411 | 416 | 420 | 425 | 427 | 434 |
| 6 | 4,520 | 416.90 | 6.84 | 402 | 409 | 412 | 416 | 422 | 427 | 428 | 436 |
| 7 | 4,475 | 418.75 | 6.73 | 402 | 410 | 414 | 419 | 424 | 427 | 429 | 438 |
| 8 | 3,585 | 419.76 | 7.14 | 401 | 410 | 414 | 420 | 425 | 429 | 431 | 440 |
| 9 | 2,257 | 419.71 | 7.86 | 403 | 410 | 414 | 419 | 426 | 430 | 433 | 442 |
| 10 | 2,260 | 421.30 | 8.22 | 403 | 411 | 415 | 421 | 428 | 433 | 434 | 442 |
| 11 | 1,789 | 422.43 | 7.37 | 402 | 413 | 417 | 422 | 428 | 433 | 435 | 442 |

**Table E.15. Science Scale Score Descriptive Statistics Based on Scaling Study by Grade**

| Grade | N | Mean | SD | Min | P10 | P25 | P50 | P75 | P90 | P95 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4,214 | 413.89 | 5.99 | 401 | 407 | 409 | 414 | 418 | 422 | 424 | 433 |
| 4 | 3,571 | 416.29 | 6.53 | 400 | 407 | 412 | 416 | 421 | 425 | 427 | 435 |
| 5 | 3,903 | 419.05 | 6.78 | 401 | 410 | 414 | 420 | 424 | 427 | 430 | 438 |
| 6 | 4,642 | 418.76 | 7.54 | 400 | 409 | 412 | 419 | 424 | 429 | 431 | 440 |
| 7 | 4,756 | 420.49 | 7.65 | 401 | 410 | 414 | 421 | 426 | 431 | 432 | 441 |
| 8 | 3,544 | 422.14 | 7.91 | 401 | 412 | 416 | 422 | 427 | 433 | 435 | 446 |
| 9 | 2,167 | 422.65 | 8.22 | 402 | 412 | 417 | 421 | 429 | 434 | 437 | 447 |
| 10 | 2,314 | 424.43 | 8.89 | 402 | 414 | 417 | 424 | 431 | 436 | 439 | 449 |
| 11 | 1,717 | 424.59 | 9.04 | 400 | 412 | 417 | 425 | 431 | 437 | 439 | 449 |

The lowest obtainable scale score (LOSS) and the highest obtainable scale score (HOSS) of the ACT Aspire scales for all subjects and grades are presented in Table E.16. Note that English, mathematics, reading, and science tests all have the same minimum scale score of 400 while the maximum scale scores vary across grade within a subject. The HOSS varies among the four subjects and also across grades. Within each subject, the HOSS increases as the grade increases.

**Table E.16. Lowest Obtainable Scale Score (LOSS) and Highest Obtainable Scale Score (HOSS)**

| Subject | Grade | LOSS | HOSS | Subject | Grade | LOSS | HOSS |
|---|---|---|---|---|---|---|---|
| English | 3 | 400 | 435 | Reading | 3 | 400 | 429 |
| | 4 | 400 | 438 | | 4 | 400 | 431 |
| | 5 | 400 | 442 | | 5 | 400 | 434 |
| | 6 | 400 | 448 | | 6 | 400 | 436 |
| | 7 | 400 | 450 | | 7 | 400 | 438 |
| | 8 | 400 | 452 | | 8 | 400 | 440 |
| | EHS | 400 | 456 | | EHS | 400 | 442 |
| Mathematics | 3 | 400 | 434 | Science | 3 | 400 | 433 |
| | 4 | 400 | 440 | | 4 | 400 | 436 |
| | 5 | 400 | 446 | | 5 | 400 | 438 |
| | 6 | 400 | 451 | | 6 | 400 | 440 |
| | 7 | 400 | 453 | | 7 | 400 | 443 |
| | 8 | 400 | 456 | | 8 | 400 | 446 |
| | EHS | 400 | 460 | | EHS | 400 | 449 |

*Note.* EHS = early high school.

# References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# Appendix F

# ACT Aspire Mode Comparability Study

For ACT Aspire, the online and paper test forms are not exactly the same, and thus, scores on the test forms from two testing modes are statistically adjusted to take into account not only the form differences, but the potential effects across paper and online testing modes. This chapter describes a score comparability study for the ACT Aspire paper and online testing modes. The study included data from a special administration of ACT Aspire that involved a randomly equivalent groups design.[1] The study examined potential effects from student taking the test in different modes and evaluated the comparability of scale scores after statistical linking. The results indicated that it was unreasonable to ignore possible mode effects, but after linking, scales scores from different modes appeared comparable.

## F.1 Introduction

A mode comparability study was undertaken to investigate ACT Aspire performance across online and paper modes. Most test forms included in this study were not identical across modes. This led us to assume that scores from paper and online forms were not interchangeable without first statistically linking test form scores across modes.

Two primary purposes of the comparability study were (a) determining whether mode of administration affected student performance on the identical[2] items across modes before scaling and (b) investigating the comparability of ACT Aspire scale scores, which were obtained after linking paper and online forms. The overarching question to address with the comparability study was related to test score validity—whether the interpretations of test scores is similar across paper and online test forms. In this chapter, we described comparisons of scores in number of points earned (on identical items), item-level performance, and scale scores across modes.

[1] This design is commonly referred as random groups design in the literature.
[2] In this writing, identical and common were used interchangeably to refer to common items across test forms.

Studying the effects of mode on performance of collections of identical items gives us an idea of the direction and degree of differences due to mode. This, in turn, can help us determine whether performance on collections of identical items across modes could be considered interchangeable without statistical linking across modes to moderate potential mode effects.

Investigating the comparability of scale scores after linking forms across modes, where items on forms are not exactly the same but may have most of the same items, provides us with evidence about (a) the effectiveness of the linking and (b) the apparent interchangeability of scale scores across forms administered in different modes. When a testing program administers test forms in different modes and when scores are used interchangeably across forms, testing program must show that scale scores are indeed comparable across forms as emphasized by Standard 5.17 of *The Standards for Educational and Psychological Testing* (AERA et al., 2014, p. 106).

# F.2 Method and Results

Test materials included one online and one paper ACT Aspire English, mathematics, reading, science, and writing test form for grades 3–10. At least 80% of items were the same[3] across modes and consisted of selected-response and constructed-response items.[4] However, most online test forms also contained a small number of technology-enhanced and fill-in-the-blank items that are not suitable for paper forms. Paper forms contained analogous selected-response items covering the same content, but these items were not considered identical across forms. Table F.1 shows the percentages of items considered different across modes. We handled these nonidentical items differently depending on the purpose of our analysis. For studying potential mode effects on the number of points students earned, we excluded such items and focused on the identical items to gauge mode effects. For studying the comparability of scale scores across modes, we included the nonidentical items because scale scores are obtained using all operational items on a form.

Participants in this study included students in grades 3 through 10 from a sample representing 13 states, 72 districts, and 108 schools. Table F.2 presents sample sizes for each subject by grade and mode. Sample sizes ranged from 645 (online grade 8 writing) to 1,539 (paper grade 3 mathematics). Tables F.3–F.7 provide percentages of demographic groupings by grade and mode.

**Table F.1. Percentage of Items Different Across Online and Paper Forms[a]**

| | Grade | | | | | | |
|---|---|---|---|---|---|---|---|
| Subject | 3 | 4 | 5 | 6 | 7 | 8 | EHS |
| English | 16% | 20% | 16% | 9% | 6% | — | — |
| Mathematics | 20% | 16% | 12% | 18% | 15% | 8% | 5% |
| Reading | 8% | 8% | 13% | 8% | 13% | — | — |
| Science | 11% | 14% | 14% | 13% | 13% | 9% | 13% |
| Writing[b] | — | — | — | — | — | — | — |

*Note.* [a] Technology-enhanced items and fill-in-the blank items were included in online forms; selected-response items that were analogs to them were included in paper forms.
[b] For writing, "—" indicates a single writing prompt was used across modes.

[3] Items contained identical content and were the same item type.
[4] English forms did not contain constructed-response items.

**Table F.2. Sample Sizes by Grade and Subject**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| Subject | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| English | 1,359 | 1,405 | 1,480 | 1,489 | 1,349 | 1,346 | 1,129 | 1,166 | 1,019 | 1,033 | 866 | 887 | 1,176 | 1,209 |
| Mathematics | 1,488 | 1,539 | 1,534 | 1,532 | 1,450 | 1,427 | 1,156 | 1,194 | 974 | 1,010 | 896 | 927 | 1,075 | 1,098 |
| Reading | 1,441 | 1,513 | 1,399 | 1,401 | 1,299 | 1,294 | 1,004 | 1,038 | 1,010 | 1,037 | 800 | 831 | 857 | 919 |
| Science | 1,376 | 1,405 | 1,435 | 1,444 | 1,378 | 1,379 | 1,047 | 1,040 | 1,028 | 1,042 | 913 | 934 | 959 | 1,023 |
| Writing | 1,189 | 1,268 | 1,260 | 1,280 | 1,101 | 1,102 | 840 | 885 | 825 | 836 | 645 | 658 | 698 | 767 |

*Note*. O = online form, P = paper form.

# F.3 Spring 2013 Comparability Study Demographic Summary Tables

Students were recruited to complete an ACT Aspire test in one or more subjects. Students at each grade within a school were randomly assigned to take either the paper or the online version of the test. This randomly equivalent groups design ensured that recruited students had an equal chance of being assigned the online or paper test within a school. If students tested in each mode are equivalent, we can attribute observed differences in performance to differences in testing mode, not to differences in groups of students (or a combination of group and performance differences).

To help ensure our analysis included adequately balanced samples of students tested in each mode, schools were included in the analysis sample only if the ratio of students testing in one mode compared to the other within the school was less than two. That was, we only included schools that had less than twice as many students tested in one mode versus the other. This data cleaning rule excluded less than 10% of students from analysis for most grades and subjects.[5] Additional details about the samples, including demographic characteristics, are included in Tables F.3–F.7.

[5] Up to 22% of students (five schools) were excluded from analysis. Grade 7 science and grade 8 writing had more than 20% of students excluded. Most excluded schools only tested in one mode.

**Table F.3. Percentages of Students Taking English Tests in the Comparability Study by Grade, Mode, and Demographics**

| | Grade Mode (N) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Demographic Grouping % | (1,359) | (1,405) | (1,480) | (1,489) | (1,349) | (1,346) | (1,129) | (1,166) | (1,019) | (1,033) | (866) | (887) | (1,176) | (1,209) |
| Gender | | | | | | | | | | | | | | |
| Not Specified | 19 | 19 | 15 | 15 | 14 | 14 | 14 | 14 | 16 | 17 | 19 | 20 | 17 | 18 |
| Female | 40 | 41 | 40 | 42 | 40 | 43 | 42 | 41 | 42 | 43 | 42 | 41 | 36 | 36 |
| Male | 41 | 40 | 45 | 44 | 45 | 43 | 43 | 45 | 42 | 41 | 39 | 40 | 47 | 45 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| Not Specified | 42 | 43 | 41 | 42 | 35 | 35 | 28 | 27 | 25 | 25 | 24 | 24 | 26 | 28 |
| Black/African American | 3 | 3 | 4 | 3 | 3 | 4 | 6 | 5 | 6 | 7 | 7 | 8 | 7 | 6 |
| American Indian/ Alaskan Native | 2 | 3 | 2 | 1 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 1 | 2 |
| White | 47 | 44 | 46 | 45 | 46 | 45 | 46 | 47 | 52 | 52 | 48 | 44 | 49 | 47 |
| Hispanic/Latino | 3 | 3 | 3 | 3 | 2 | 3 | 5 | 6 | 4 | 3 | 6 | 6 | 5 | 6 |
| Asian | 1 | 1 | 2 | 2 | 3 | 2 | 4 | 3 | 4 | 3 | 6 | 7 | 5 | 5 |
| Native Hawaiian/ Other Pacific Islander | 2 | 2 | 3 | 2 | 8 | 8 | 8 | 7 | 6 | 7 | 6 | 6 | 5 | 5 |
| Two or More Races | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Geographic Region | | | | | | | | | | | | | | |
| East | 73 | 74 | 70 | 69 | 65 | 64 | 51 | 54 | 55 | 56 | 54 | 54 | 60 | 58 |
| Midwest | 12 | 12 | 13 | 13 | 21 | 20 | 23 | 22 | 22 | 21 | 13 | 13 | 31 | 33 |
| Southwest | 9 | 8 | 11 | 12 | 8 | 8 | 17 | 16 | 18 | 17 | 22 | 22 | 2 | 2 |
| West | 6 | 6 | 6 | 7 | 7 | 7 | 9 | 9 | 5 | 6 | 11 | 11 | 7 | 7 |

*Note*. O = online; P = paper. Zero indicates less than 0.5%. Missing values indicate no students for a cell. Percentages within a demographic grouping may not add up to 100% due to rounding.

**Table F.4. Percentages of Students Taking Mathematics Tests in the Comparability Study by Grade, Mode, and Demographics**

| | Grade Mode (N) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Demographic Grouping % | (1,488) | (1,539) | (1,534) | (1,532) | (1,450) | (1,427) | (1,156) | (1,194) | (974) | (1,010) | (896) | (927) | (1,075) | (1,098) |
| Gender | | | | | | | | | | | | | | |
| Not Specified | 17 | 17 | 16 | 16 | 14 | 14 | 14 | 14 | 17 | 17 | 19 | 19 | 14 | 15 |
| Female | 40 | 42 | 40 | 41 | 40 | 43 | 43 | 42 | 40 | 42 | 42 | 41 | 37 | 38 |
| Male | 42 | 42 | 44 | 43 | 46 | 43 | 43 | 45 | 42 | 41 | 39 | 40 | 49 | 48 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| Not Specified | 42 | 42 | 41 | 42 | 33 | 33 | 37 | 36 | 26 | 26 | 23 | 24 | 21 | 22 |
| Black/African American | 5 | 5 | 6 | 5 | 6 | 7 | 5 | 5 | 6 | 8 | 6 | 8 | 5 | 6 |
| American Indian/ Alaskan Native | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 |
| White | 44 | 42 | 43 | 43 | 46 | 45 | 42 | 43 | 51 | 50 | 49 | 46 | 54 | 51 |
| Hispanic/Latino | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 5 | 6 | 6 | 6 |
| Asian | 2 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 4 | 3 | 5 | 7 | 6 | 6 |
| Native Hawaiian/ Other Pacific Islander | 3 | 3 | 2 | 2 | 7 | 7 | 6 | 7 | 6 | 7 | 6 | 5 | 5 | 6 |
| Two or More Races | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Geographic Region | | | | | | | | | | | | | | |
| East | 74 | 75 | 71 | 72 | 67 | 67 | 50 | 50 | 56 | 55 | 56 | 56 | 60 | 59 |
| Midwest | 11 | 11 | 12 | 11 | 20 | 19 | 29 | 30 | 20 | 21 | 13 | 12 | 30 | 31 |
| Southwest | 11 | 10 | 10 | 11 | 7 | 8 | 16 | 15 | 17 | 18 | 19 | 21 | 2 | 2 |
| West | 3 | 4 | 6 | 6 | 7 | 6 | 5 | 5 | 6 | 6 | 12 | 11 | 8 | 7 |

*Note*. O = online; P = paper. Zero indicates less than 0.5%. Missing values indicate no students for a cell. Percentages within a demographic grouping may not add up to 100% due to rounding.

**Table F.5. Percentages of Students Taking Reading Tests in the Comparability Study by Grade, Mode, and Demographics**

| | Grade Mode (N) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Demographic Grouping % | (1,441) | (1,513) | (1,399) | (1,401) | (1,299) | (1,294) | (1,004) | (1,038) | (1,010) | (1,037) | (800) | (831) | (857) | (919) |
| Gender | | | | | | | | | | | | | | |
| Not Specified | 15 | 15 | 16 | 16 | 13 | 13 | 13 | 13 | 13 | 14 | 20 | 21 | 18 | 18 |
| Female | 42 | 42 | 40 | 41 | 40 | 43 | 44 | 41 | 43 | 44 | 41 | 39 | 35 | 33 |
| Male | 43 | 42 | 44 | 43 | 47 | 44 | 43 | 46 | 44 | 42 | 39 | 39 | 47 | 49 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| Not Specified | 42 | 44 | 42 | 43 | 32 | 33 | 32 | 32 | 25 | 25 | 24 | 25 | 27 | 27 |
| Black/African American | 5 | 6 | 6 | 4 | 6 | 7 | 6 | 6 | 6 | 7 | 8 | 9 | 7 | 7 |
| American Indian/ Alaskan Native | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| White | 45 | 42 | 46 | 47 | 48 | 48 | 47 | 45 | 52 | 50 | 46 | 43 | 41 | 43 |
| Hispanic/Latino | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 6 | 6 | 7 | 7 |
| Asian | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 5 | 4 | 5 | 6 | 7 | 6 |
| Native Hawaiian/ Other Pacific Islander | 2 | 1 | 1 | 1 | 7 | 6 | 5 | 6 | 3 | 4 | 7 | 6 | 6 | 6 |
| Two or More Races | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| Geographic Region | | | | | | | | | | | | | | |
| East | 77 | 77 | 78 | 79 | 74 | 74 | 58 | 58 | 54 | 54 | 49 | 50 | 53 | 52 |
| Midwest | 12 | 11 | 14 | 14 | 22 | 21 | 24 | 25 | 23 | 22 | 15 | 15 | 35 | 36 |
| Southwest | 11 | 11 | 8 | 7 | 4 | 4 | 18 | 17 | 16 | 17 | 23 | 24 | 3 | 3 |
| West | | | | | | | | | 7 | 7 | 13 | 12 | 9 | 9 |

*Note*. O = online; P = paper. Zero indicates less than 0.5%. Missing values indicate no students for a cell. Percentages within a demographic grouping may not add up to 100% due to rounding

**Table F.6. Percentages of Students Taking Science Tests in the Comparability Study by Grade, Mode, and Demographics**

| | Grade Mode (N) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Demographic Grouping % | (1,376) | (1,405) | (1,435) | (1,444) | (1,378) | (1,379) | (1,047) | (1,040) | (1,028) | (1,042) | (913) | (934) | (959) | (1,023) |
| Gender | | | | | | | | | | | | | | |
| Not Specified | 19 | 18 | 15 | 15 | 14 | 14 | 15 | 16 | 16 | 17 | 18 | 19 | 21 | 21 |
| Female | 40 | 41 | 40 | 41 | 40 | 42 | 42 | 40 | 42 | 43 | 43 | 41 | 34 | 33 |
| Male | 42 | 41 | 45 | 44 | 46 | 45 | 43 | 45 | 43 | 40 | 39 | 40 | 45 | 46 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| Not Specified | 48 | 47 | 42 | 43 | 35 | 36 | 31 | 31 | 27 | 27 | 23 | 23 | 33 | 34 |
| Black/African American | 1 | 1 | 2 | 1 | 2 | 3 | 6 | 6 | 6 | 7 | 7 | 8 | 5 | 4 |
| American Indian/ Alaskan Native | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 2 | 4 | 3 | 2 | 3 |
| White | 42 | 40 | 47 | 48 | 48 | 47 | 46 | 46 | 50 | 50 | 49 | 47 | 41 | 41 |
| Hispanic/Latino | 2 | 2 | 2 | 2 | 2 | 1 | 5 | 5 | 3 | 3 | 5 | 6 | 6 | 6 |
| Asian | 2 | 3 | 2 | 2 | 3 | 2 | 4 | 3 | 4 | 3 | 6 | 6 | 7 | 5 |
| Native Hawaiian/ Other Pacific Islander | 3 | 3 | 3 | 2 | 8 | 8 | 4 | 5 | 6 | 7 | 6 | 5 | 5 | 6 |
| Two or More Races | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 2 |
| Geographic Region | | | | | | | | | | | | | | |
| East | 73 | 74 | 74 | 73 | 68 | 68 | 55 | 57 | 54 | 53 | 55 | 55 | 45 | 45 |
| Midwest | 13 | 12 | 14 | 13 | 22 | 21 | 21 | 20 | 25 | 24 | 13 | 13 | 45 | 45 |
| Southwest | 12 | 12 | 11 | 12 | 8 | 8 | 18 | 18 | 16 | 17 | 21 | 21 | 3 | 2 |
| West | 2 | 2 | 2 | 2 | 2 | 2 | 7 | 5 | 5 | 6 | 11 | 11 | 8 | 8 |

*Note*. O = online; P = paper. Zero indicates less than 0.5%. Missing values indicate no students for a cell. Percentages within a demographic grouping may not add up to 100% due to rounding

**Table F.7. Percentages of Students Taking Writing Tests in the Comparability Study by Grade, Mode, and Demographics**

| | Grade Mode (N) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Demographic Grouping % | (1,189) | (1,268) | (1,260) | (1,280) | (1,101) | (1,102) | (840) | (885) | (825) | (836) | (645) | (658) | (698) | (767) |
| Gender | | | | | | | | | | | | | | |
| Not Specified | 17 | 16 | 14 | 13 | 13 | 12 | 16 | 15 | 16 | 17 | 21 | 23 | 26 | 27 |
| Female | 41 | 42 | 41 | 42 | 41 | 44 | 41 | 41 | 42 | 43 | 42 | 39 | 29 | 28 |
| Male | 41 | 41 | 45 | 45 | 46 | 44 | 43 | 44 | 42 | 40 | 37 | 38 | 45 | 45 |
| Race/Ethnicity | | | | | | | | | | | | | | |
| Not Specified | 47 | 49 | 46 | 47 | 40 | 40 | 37 | 36 | 29 | 31 | 30 | 31 | 39 | 38 |
| Black/African American | 3 | 3 | 3 | 2 | 3 | 3 | 6 | 5 | 6 | 7 | 7 | 9 | 5 | 6 |
| American Indian/ Alaskan Native | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 4 | 3 | 3 |
| White | 45 | 42 | 46 | 46 | 47 | 48 | 46 | 45 | 55 | 53 | 51 | 48 | 47 | 47 |
| Hispanic/Latino | 1 | 2 | 2 | 2 | 1 | 1 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 5 |
| Asian | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 0 |
| Native Hawaiian/ Other Pacific Islander | 0 | 0 | 0 | 0 | 6 | 5 | 3 | 4 | 1 | 1 | | 0 | | 0 |
| Two or More Races | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Geographic Region | | | | | | | | | | | | | | |
| East | 74 | 75 | 73 | 73 | 66 | 65 | 52 | 51 | 51 | 53 | 53 | 55 | 44 | 44 |
| Midwest | 14 | 13 | 16 | 15 | 25 | 25 | 27 | 28 | 26 | 26 | 18 | 17 | 53 | 53 |
| Southwest | 12 | 12 | 11 | 12 | 10 | 10 | 22 | 20 | 23 | 21 | 30 | 28 | 3 | 3 |
| West | | | | | | | | | | | | | | |

*Note*. O = online; P = paper. Zero indicates less than 0.5%. Missing values indicate no students for a cell. Percentages within a demographic grouping may not add up to 100% due to rounding

# F.4 Mode Effects for Raw Scores on Common Items

We investigated student raw score performance by summing scores from items that were the same across paper and online forms (excluding items that differed in item type across modes). English and writing showed more consistent evidence of mode effects across grades compared to mathematics, reading, and science. But for some subjects and grades, raw scores appeared to differ across modes, and for others they did not. It is apparent from these results that it was not safe to assume raw scores and raw score distributions on identical items across modes were comparable.

Tables F.8–F.12 summarize the aggregated raw score statistics for the common items across modes, including score moments (mean, standard deviation, skewness, and kurtosis), effect sizes (standardized differences in mean scores), and statistical significance tests from tests of equivalence (for details on this test, see Rogers, Howard & Vessey, 1993; Serlin & Lapsley, 1985; see also the Kolmogorov-Smirnov test of differences in cumulative distributions by subject).

**Table F.8. English Common-Item Raw Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of common items | 21 | 21 | 20 | 20 | 21 | 21 | 32 | 32 | 33 | 33 | 35 | 35 | 50 | 50 |
| Sample size | 1,359 | 1,405 | 1,480 | 1,489 | 1,349 | 1,346 | 1,129 | 1,166 | 1,019 | 1,033 | 866 | 887 | 1,176 | 1,209 |
| Raw score | | | | | | | | | | | | | | |
| Mean | 11.65 | 10.07 | 11.44 | 11.06 | 11.21 | 10.61 | 16.52 | 14.84 | 17.44 | 16.41 | 21.91 | 22.06 | 25.75 | 25.54 |
| SD | 4.14 | 4.05 | 3.50 | 3.77 | 4.15 | 4.04 | 5.32 | 5.32 | 5.92 | 5.85 | 5.97 | 6.52 | 9.96 | 9.81 |
| Minimum | 1 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 4 | 2 | 5 | 3 | 4 | 3 |
| Maximum | 21 | 20 | 20 | 20 | 21 | 20 | 32 | 30 | 32 | 33 | 34 | 34 | 49 | 50 |
| Skewness | 0.00 | 0.36 | -0.09 | -0.11 | 0.11 | 0.09 | 0.14 | 0.30 | 0.02 | 0.24 | -0.32 | -0.43 | 0.20 | 0.16 |
| Kurtosis | -0.68 | -0.64 | -0.65 | -0.57 | -0.71 | -0.67 | -0.34 | -0.38 | -0.62 | -0.49 | -0.51 | -0.54 | -0.82 | -0.75 |
| Reliability | .79 | .78 | .75 | .78 | .79 | .78 | .80 | .80 | .81 | .81 | .83 | .86 | .91 | .90 |
| Effect size | 0.39 | | 0.11 | | 0.15 | | 0.32 | | 0.18 | | -0.02 | | 0.02 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 4.68* | | 1.45* | | 1.66* | | 3.47* | | 1.90* | | 1.12 | | 0.56 | |
| T-test t-statistic (df) | 10.15* (2,762) | | 2.87* (2,967) | | 3.80* (2,693) | | 7.58* (2,293) | | 3.99* (2,050) | | -0.51 (1,751) | | 0.51 (2,383) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.9. Mathematics Common-Item Raw Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of common items | 20 | 20 | 21 | 21 | 22 | 22 | 28 | 28 | 29 | 29 | 35 | 35 | 36 | 36 |
| Sample size | 1,488 | 1,539 | 1,534 | 1,532 | 1,450 | 1,427 | 1,156 | 1,194 | 974 | 1,010 | 896 | 927 | 1,075 | 1,098 |
| Raw score | | | | | | | | | | | | | | |
| Mean | 12.42 | 12.61 | 9.53 | 9.48 | 10.00 | 9.99 | 12.27 | 12.01 | 13.31 | 13.91 | 18.96 | 19.75 | 17.60 | 18.14 |
| SD | 4.68 | 4.77 | 3.46 | 3.39 | 3.49 | 3.34 | 4.13 | 4.11 | 5.51 | 5.57 | 7.16 | 7.18 | 8.21 | 8.15 |
| Minimum | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 1 | 2 | 1 | 1 | 1 | 3 | 1 |
| Maximum | 26 | 27 | 25 | 27 | 26 | 23 | 31 | 29 | 34 | 32 | 42 | 39 | 44 | 45 |
| Skewness | 0.17 | 0.16 | 0.60 | 0.62 | 0.58 | 0.32 | 0.53 | 0.36 | 0.61 | 0.55 | 0.25 | 0.03 | 0.48 | 0.45 |
| Kurtosis | -0.29 | -0.41 | 1.00 | 1.12 | 0.69 | 0.24 | 0.51 | 0.25 | 0.20 | -0.03 | -0.37 | -0.55 | -0.47 | -0.46 |
| Reliability | .76 | .75 | .64 | .62 | .67 | .63 | .74 | .73 | .82 | .83 | .87 | .87 | .88 | .87 |
| Effect size | -0.04 | | 0.02 | | 0.00 | | 0.06 | | -0.11 | | -0.11 | | -0.07 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.05 | | 0.43 | | 0.96 | | 0.84 | | 1.25 | | 1.47* | | 0.73 | |
| T-test t-statistic (df) | -1.09 (3,025) | | 0.46 (3,064) | | 0.07 (2,875) | | 1.54 (2,348) | | -2.39* (1,982) | | -2.35* (1,821) | | -1.53 (2,171) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.10. Reading Common-Item Raw Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of common items | 22 | 22 | 22 | 22 | 21 | 21 | 22 | 22 | 21 | 21 | 24 | 24 | 24 | 24 |
| Sample size | 1,441 | 1,513 | 1,399 | 1,401 | 1,299 | 1,294 | 1,004 | 1,038 | 1,010 | 1,037 | 800 | 831 | 857 | 919 |
| Raw score | | | | | | | | | | | | | | |
| Mean | 12.93 | 13.99 | 13.30 | 14.32 | 12.94 | 12.82 | 14.56 | 14.69 | 11.96 | 12.31 | 16.39 | 15.96 | 15.17 | 15.20 |
| SD | 5.75 | 5.68 | 5.66 | 5.69 | 5.13 | 5.03 | 5.44 | 5.15 | 5.20 | 5.31 | 6.25 | 6.41 | 6.87 | 6.99 |
| Minimum | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 1 | 1 | 1 | 1 |
| Maximum | 26 | 26 | 26 | 26 | 25 | 24 | 26 | 26 | 25 | 24 | 29 | 30 | 30 | 31 |
| Skewness | 0.09 | -0.15 | 0.10 | -0.14 | 0.05 | -0.08 | -0.11 | -0.21 | 0.15 | 0.04 | -0.04 | -0.16 | 0.01 | -0.02 |
| Kurtosis | -1.01 | -0.88 | -0.91 | -0.87 | -0.82 | -0.81 | -0.91 | -0.82 | -0.81 | -0.94 | -0.88 | -0.86 | -1.07 | -1.10 |
| Reliability | .85 | .84 | .83 | .83 | .83 | .83 | .83 | .81 | .80 | .81 | .83 | .84 | .87 | .88 |
| Effect size | -0.19 | | -0.18 | | 0.02 | | -0.03 | | -0.07 | | 0.07 | | 0.00 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 2.76* | | 2.48* | | 0.52 | | 0.68 | | 0.96 | | 0.73 | | 0.47 | |
| T-test t-statistic (df) | -5.06* (2,952) | | -4.76* (2,798) | | 0.57 (2,591) | | -0.59 (2,040) | | -1.51 (2,045) | | 1.38 (1,629) | | -0.10 (1,774) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.11. Science Common-Item Raw Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of common items | 25 | 25 | 24 | 24 | 24 | 24 | 28 | 28 | 28 | 28 | 29 | 29 | 28 | 28 |
| Sample size | 1,376 | 1,405 | 1,435 | 1,444 | 1,378 | 1,379 | 1,047 | 1,040 | 1,028 | 1,042 | 913 | 934 | 959 | 1,023 |
| Raw score | | | | | | | | | | | | | | |
| Mean | 12.43 | 12.69 | 13.94 | 14.15 | 15.17 | 14.97 | 17.25 | 17.04 | 14.95 | 15.18 | 16.80 | 16.93 | 13.18 | 14.04 |
| SD | 7.07 | 6.77 | 5.63 | 5.74 | 6.28 | 6.25 | 7.30 | 7.30 | 7.59 | 7.34 | 7.11 | 7.28 | 6.80 | 7.20 |
| Minimum | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| Maximum | 32 | 32 | 30 | 30 | 32 | 29 | 35 | 35 | 35 | 33 | 36 | 36 | 35 | 36 |
| Skewness | 0.52 | 0.52 | 0.27 | 0.23 | 0.02 | 0.02 | 0.21 | 0.09 | 0.42 | 0.35 | 0.19 | 0.15 | 0.76 | 0.61 |
| Kurtosis | -0.60 | -0.51 | -0.54 | -0.57 | -0.80 | -0.84 | -0.79 | -0.86 | -0.80 | -0.88 | -0.78 | -0.71 | -0.21 | -0.33 |
| Reliability | .88 | .88 | .84 | .84 | .85 | .85 | .88 | .88 | .89 | .89 | .87 | .87 | .87 | .87 |
| Effect size | -0.04 | | -0.04 | | 0.03 | | 0.03 | | -0.03 | | -0.02 | | -0.12 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.22 | | 0.71 | | 0.54 | | 0.59 | | 0.89 | | 0.59 | | 1.69* | |
| T-test t-statistic (df) | -1.00 (2,779) | | -0.99 (2,877) | | 0.83 (2,755) | | 0.64 (2,085) | | -0.70 (2,068) | | -0.39 (1,845) | | -2.72* (1,980) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.12. Writing Common-Item Raw Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of common items | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Sample size | 1,189 | 1,268 | 1,260 | 1,280 | 1,101 | 1,102 | 840 | 885 | 825 | 836 | 645 | 658 | 698 | 767 |
| Raw score | | | | | | | | | | | | | | |
| Mean | 11.10 | 11.80 | 11.18 | 10.72 | 11.44 | 12.21 | 13.55 | 14.48 | 12.38 | 13.29 | 12.18 | 11.94 | 12.38 | 12.27 |
| SD | 3.53 | 3.01 | 3.56 | 3.13 | 3.74 | 3.27 | 3.95 | 3.44 | 3.87 | 3.33 | 3.50 | 3.18 | 3.65 | 3.57 |
| Minimum | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Maximum | 20 | 20 | 20 | 20 | 20 | 20 | 23 | 24 | 24 | 24 | 23 | 24 | 24 | 24 |
| Skewness | 0.21 | 0.03 | -0.07 | 0.23 | 0.08 | -0.13 | -0.14 | -0.37 | 0.27 | 0.17 | -0.20 | -0.01 | 0.02 | 0.04 |
| Kurtosis | -0.37 | -0.20 | -0.52 | -0.33 | -0.28 | -0.16 | -0.32 | -0.03 | 0.09 | 0.21 | -0.20 | 0.31 | 0.12 | 0.10 |
| Reliability | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Effect size | -0.21 | | 0.14 | | -0.22 | | -0.25 | | -0.25 | | 0.07 | | 0.03 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 3.27* | | 2.40* | | 2.65* | | 3.12* | | 2.64* | | 1.59* | | 0.86 | |
| T-test t-statistic (df) | -5.28* (2,455) | | 3.40* (2,583) | | -5.19* (2,201) | | -5.23* (1,723) | | -5.16* (1,659) | | 1.27 (1,301) | | 0.57 (1,463) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

Figure F.1 displays the cumulative percentage of students at each raw score by mode for each subject and grade. The solid curve represents the online form, and the dashed curve represents the paper form. When one of the plotted cumulative percentage curves is to the left of the other, it indicates that this group scored lower relative to the group to the right. If curves cross, or if the relative position of curves varies across raw scores, it indicates that the cumulative percentage of students between groups varies across scores. The distance between the two curves indicates the magnitude of difference between modes (difference in cumulative percentage in the vertical direction, difference in raw score in the horizontal direction). For example, for grade 3 English, the online cumulative percentage curve is to the right of the paper curve, which means that online students scored higher. Reading up from a raw score point of 10, one could see that approximately 40% of online students scored 10 or lower, whereas approximately 60% of paper students scored 10 or lower. By subtracting these percentages from 100, one could say that approximately 60% of online students scored above a score of 10, but about 40% of students testing on paper scored above a score of 10. A statistical test of the differences in cumulative distributions is provided by the Kolmogorov-Smirnov test listed in Table F.8.

English raw scores and distributions showed evidence of differences across modes in grades 3, 5, 6, and 7, including means differing by more than one point, effect sizes ranging between 0.15 and 0.39,[6] and statistically significant differences in score distributions (see Kolmogorov-Smirnov test results). Although there was inconsistency across statistics, grade 4 did show some evidence of mode effects with the result from the Kolmogorov-Smirnov test, which was statistically significant indicating that score distributions differed (see also Figure F.1 for a plot of the score distributions). Students taking online tests scored higher than students taking paper tests for grades where differences were evident.

Mathematics raw scores and distributions showed evidence of differences across modes in grades 7, 8, and EHS; the paper group scored higher than the online group. The test of equivalence indicated that mean scores from one mode were not statistically similar to those from another. The score distributions differed statistically at grade 8; Figure F.1 also depicted the difference. However, the magnitudes of differences across modes were relatively small; means differed by less than one point, and effect sizes were within ±0.15.

Reading raw scores and distributions showed evidence of differences across modes in grades 3 and 4; the paper group scored higher than the online group. Means differed by more than one point, effect sizes were −0.19 and −0.18, differences in score distributions were statistically significant, and similarities in mean scores were not statistically significant.

Science raw scores and distributions did not appear to differ across modes for all grades except for the EHS forms, where distributions were statistically different and means were not statistically similar. However, the difference was not large; means favored paper by less than one point, and the effect size was −0.12.

For writing raw scores and distributions, results showed differences across modes for all grades except EHS. Forms showed statistically significant differences in distributions in grades 3–8. Tests of equivalence did not show evidence that means were similar for grades 3, 4, 5, 6, or 7. However, means differed by less than one point for all but grade 7. Effect sizes were within ±.15 for grades 4, 8, and EHS and were between −0.20 and −0.30 for grades 3, 4, 5, and 7. Students who took paper tests scored

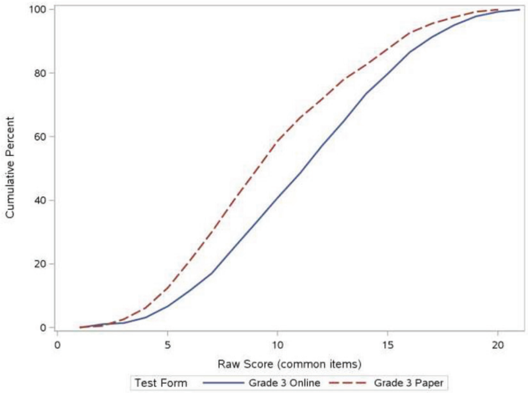
[6] We judged effect sizes of ±.15 to be small to negligible.

higher than students who took online tests in grades 3, 5, 6, and 7, and students who took online tests scored higher than those who took paper tests in grades 4 and 8.

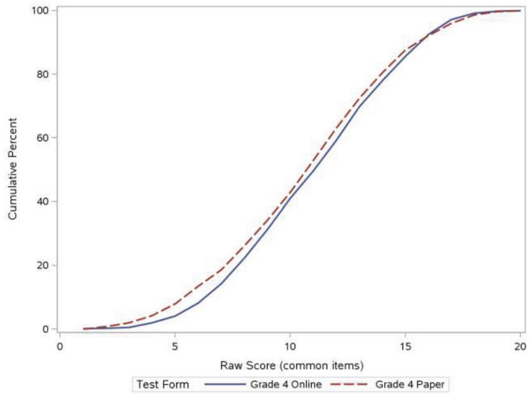
In many cases, the different methods of checking mode effects for the number of points students earned on common items led to slightly different grades in each subject, showing statistically significant mode effects. While typically not large, there were statistically significant differences across modes observed in each subject area.

Our interpretation of the comparisons of number of points earned based on identical items across modes is that mode effects observed for these ACT Aspire forms should not be ignored. Score differences were not always observed, and when they were observed, they were generally not large, but we would argue that it is unreasonable to assume there were no mode effects across collections of identical items. If two ACT Aspire forms did contain identical items, we would recommend additional statistical linking to adjust for mode effects. However, as mentioned earlier, most ACT Aspire online and paper forms are not identical, so regardless of mode effects, best practices would involve linking to place forms on the same scale (Kingston, 2009).

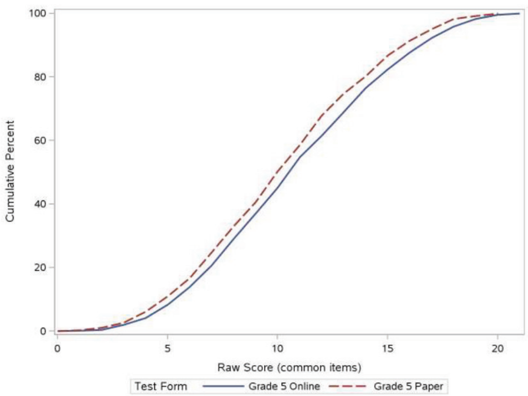
### English Grade 3



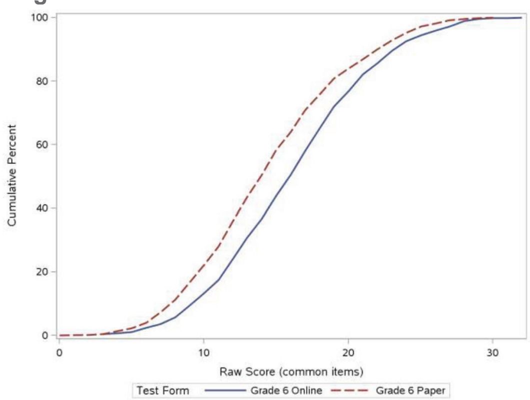

### English Grade 4



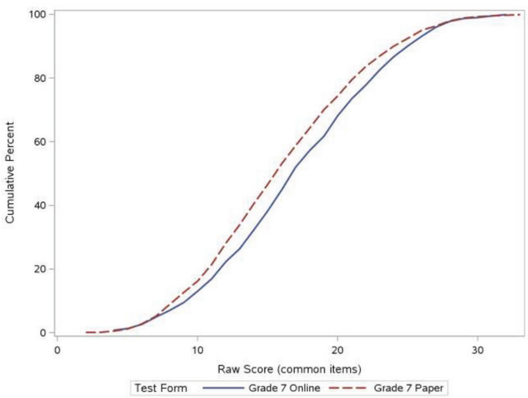

### English Grade 5



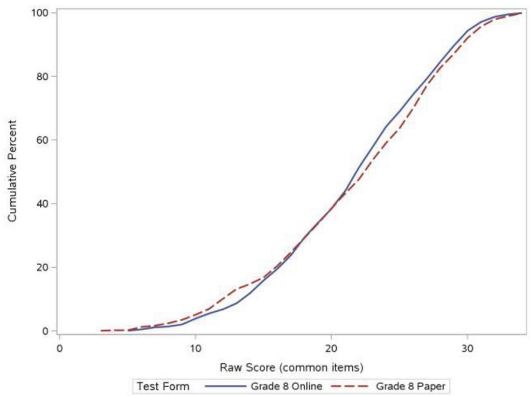

### English Grade 6




### English Grade 7




### English Grade 8




### English Early High School

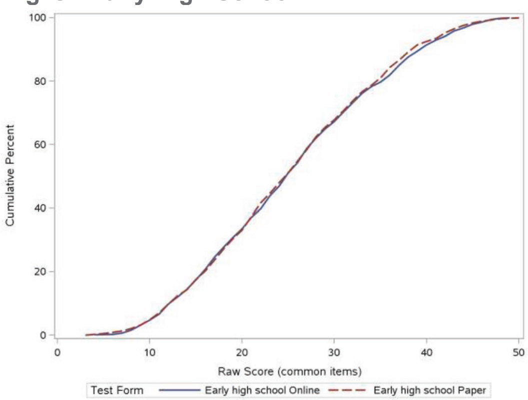
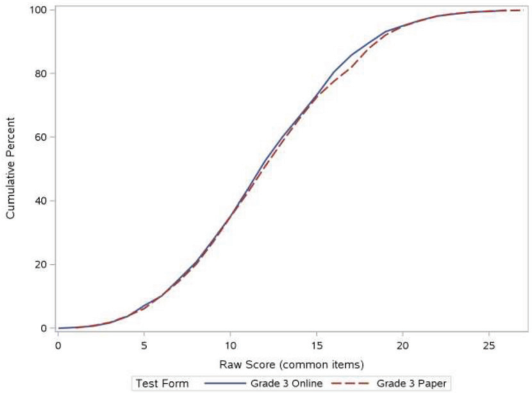
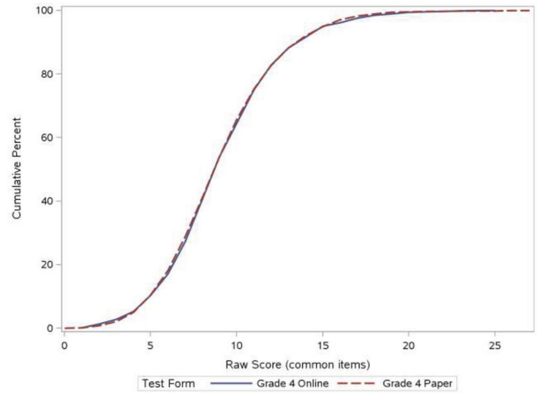



**Figure F.1. Cumulative percentage of students for common item raw scores across modes.**

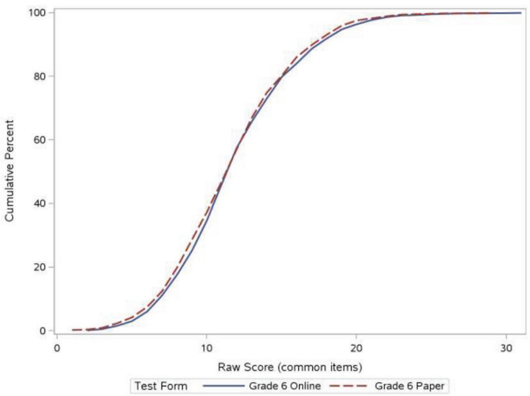
### Mathematics Grade 3



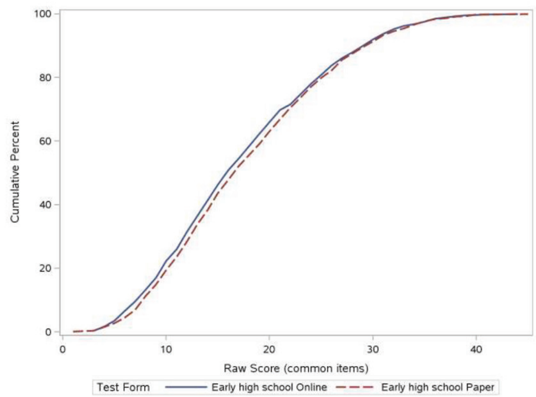

### Mathematics Grade 4



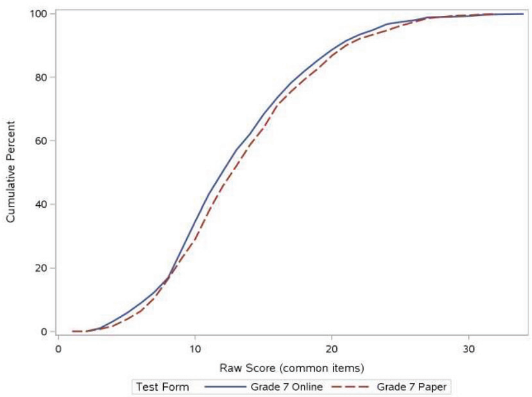

### Mathematics Grade 5



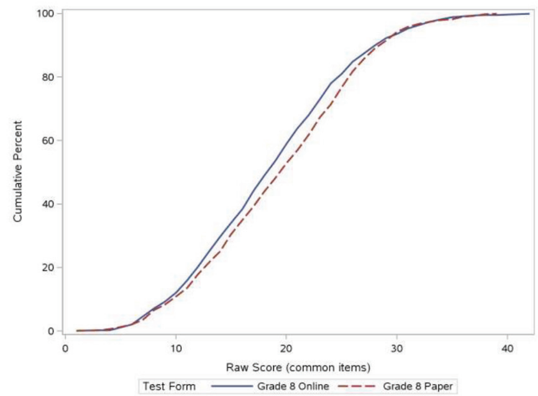

### Mathematics Grade 6




### Mathematics Grade 7




### Mathematics Grade 8




### Mathematics Early High School

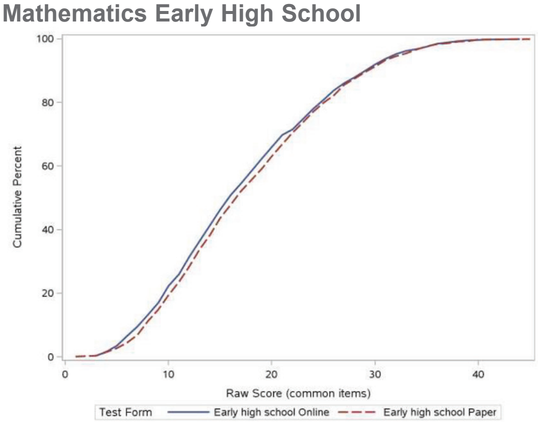
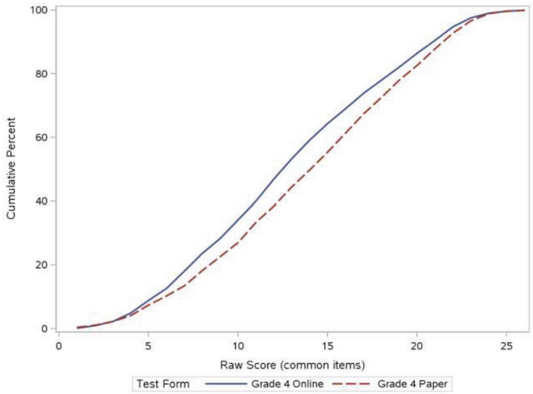
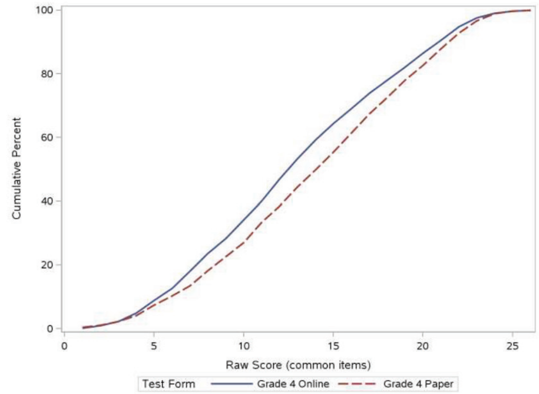



**Figure F.1. Cumulative percentage of students for common item raw scores across modes—continued.**

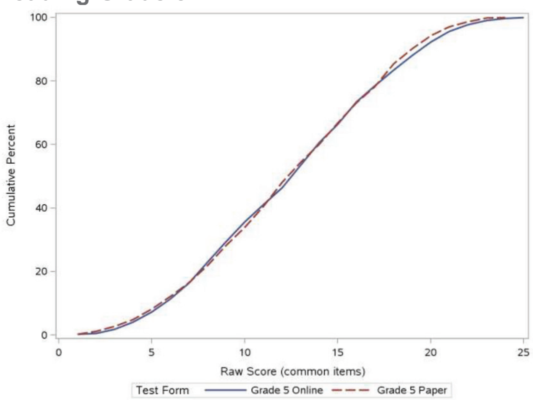
### Reading Grade 3



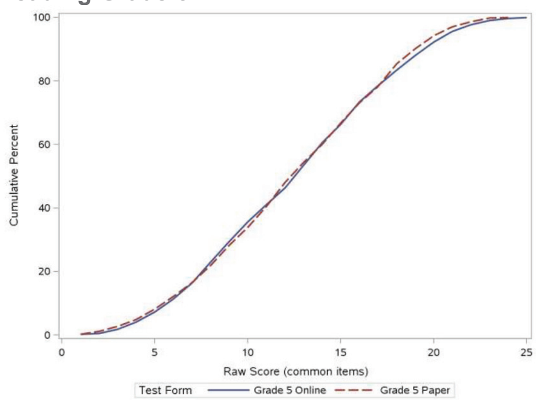

### Reading Grade 4



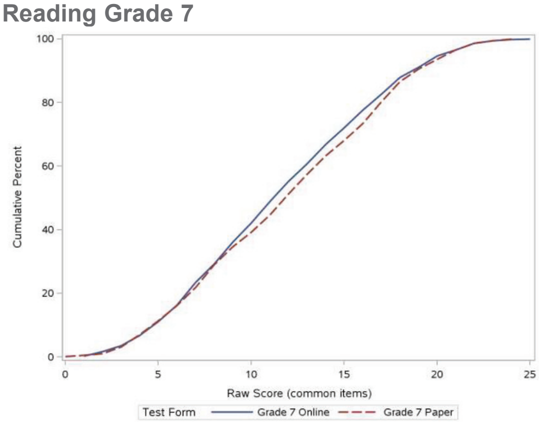

### Reading Grade 5



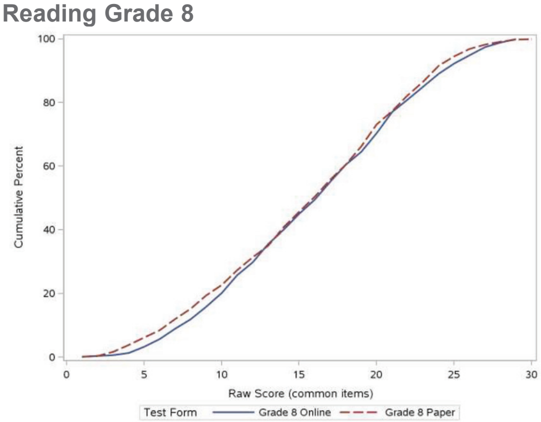

### Reading Grade 6




### Reading Grade 7




### Reading Grade 8




### Reading Early High School

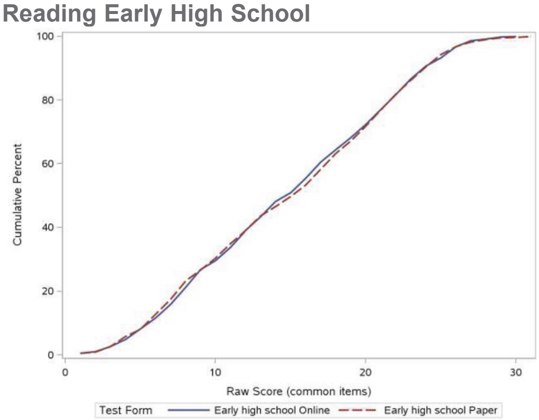
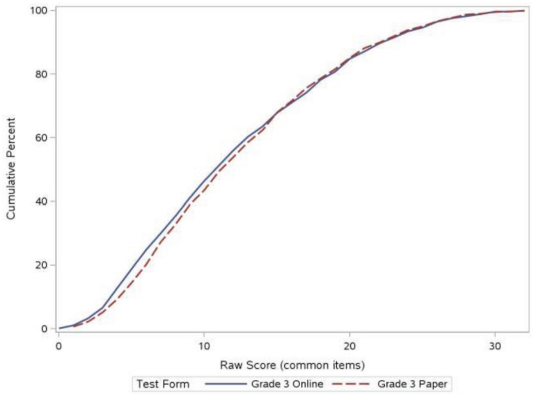
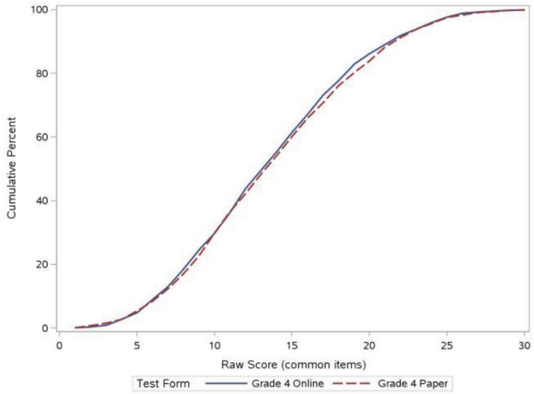



**Figure F.1. Cumulative percentage of students for common item raw scores across modes—continued.**

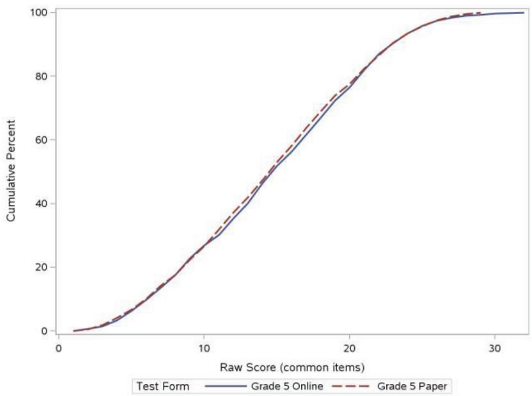
### Science Grade 3



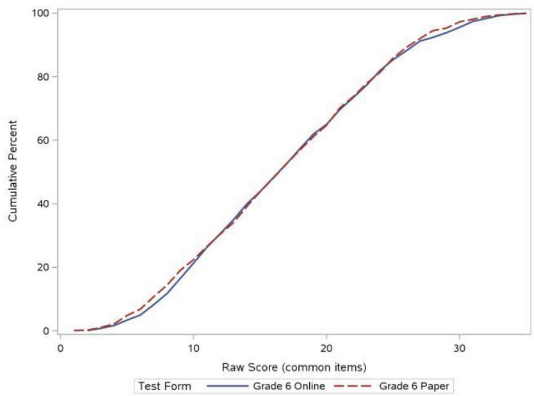

### Science Grade 4



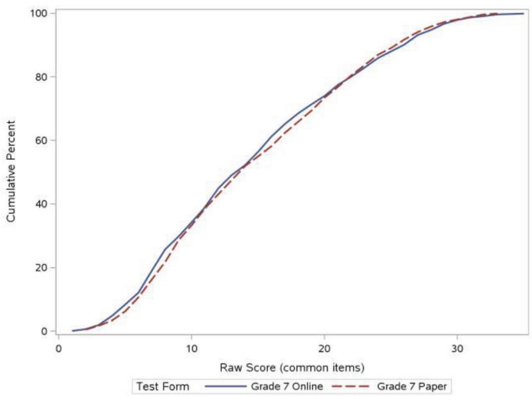

### Science Grade 5



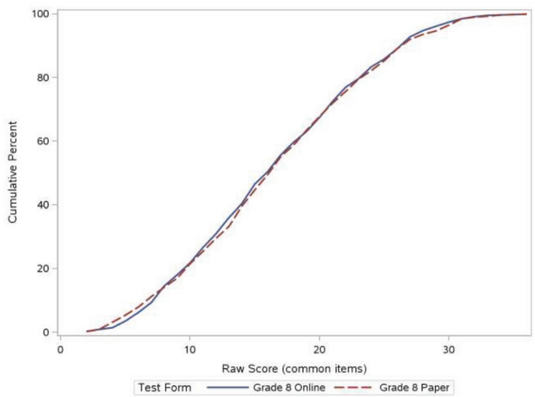

### Science Grade 6




### Science Grade 7




### Science Grade 8




### Science Early High School

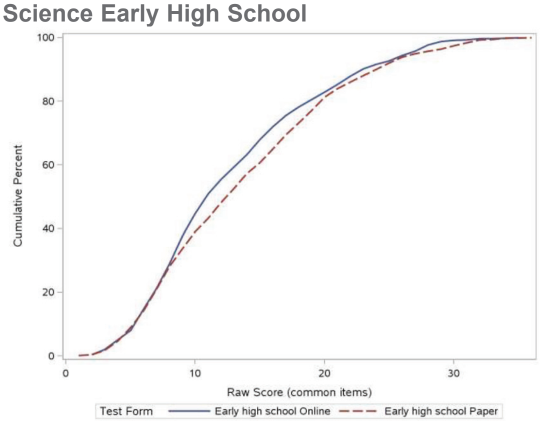
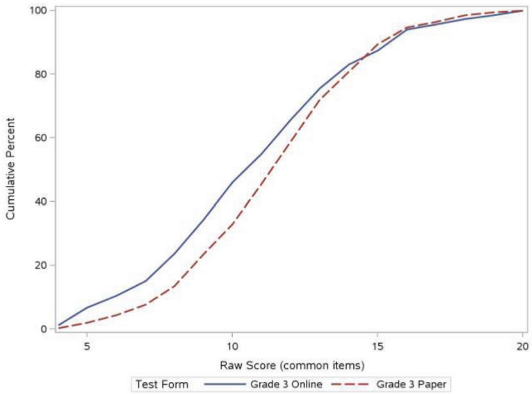
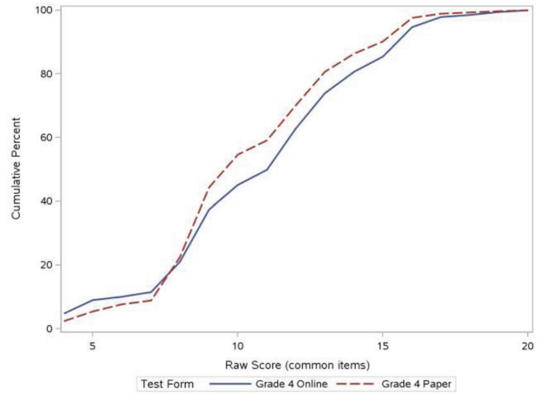



**Figure F.1. Cumulative percentage of students for common item raw scores across modes—continued.**

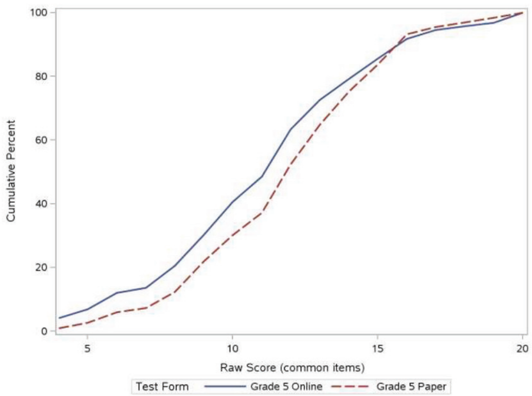
### Writing Grade 3



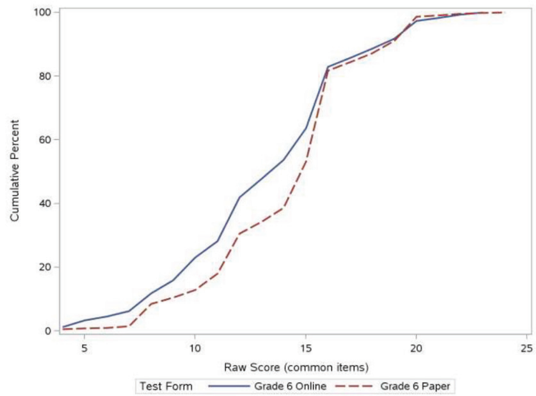

### Writing Grade 4



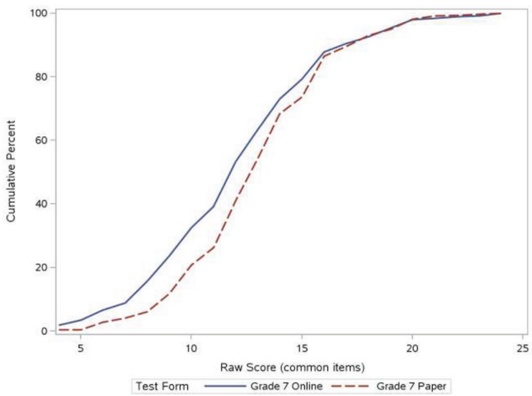

### Writing Grade 5



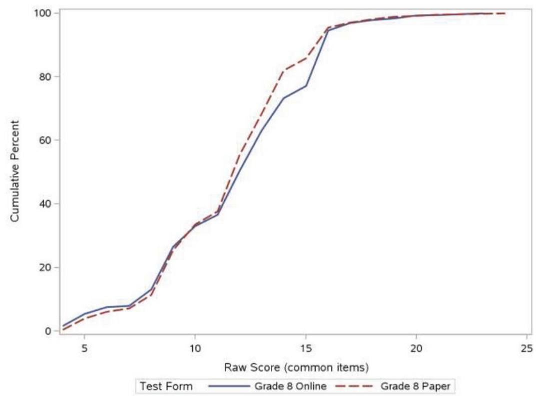

### Writing Grade 6




### Writing Grade 7




### Writing Grade 8




### Writing Early High School

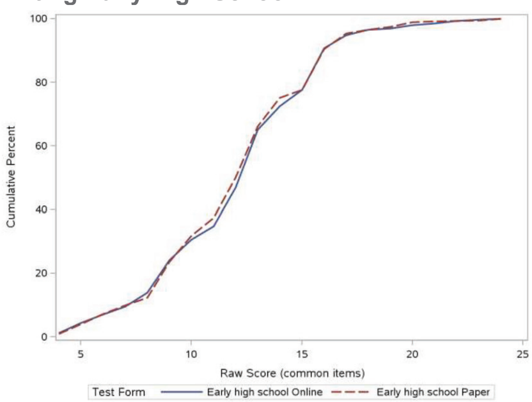



**Figure F.1. Cumulative percentage of students for common item raw scores across modes—continued.**

# F.5 Item-Level Performance Across Modes

To compare item-level performance across modes, two sets of results were presented. Plots of item statistics were to examine patterns of item-level performance across modes. Item statistics from one mode were compared to those from another mode to determine which individual item statistics were unusually high or low compared to all items.

**Item statistics.** Figures F.2–F.5 display the mean number of points[7] students earned for common items across online (horizontal axis) and paper (vertical axis) forms. For selected-response items, these statistics are often referred to as *p*-values. Each letter in the plot represents an item (M = selected-response items, X = constructed-response items). The plots illustrate patterns in the item difficulty for items across modes. For example, if the mean item performance did not differ across modes (i.e., online item mean = paper item mean), items would fall along a diagonal line from lower left to upper right. Or if one mode were harder than the other, we would see all the items cluster above or below an imaginary line drawn through the diagonal (online = paper). We are unlikely to observe either pattern exactly across modes, but these plots can provide a better understanding of the relationship between items across modes to identify (a) the strength of the item relationship in terms of difficulty and (b) whether there are particular items that were unusually difficult or easy in one mode compared to the other.

Even though the scales on the plots for English have a smaller range, item mean differences across modes clearly tended to be larger in English than in other subjects. This was consistent with the number-of-points results described above, where English showed more evidence of mode effects. In addition, there were some items that appeared unusually difficult, and the most pervasive differences appeared in English, particularly grades 3 and 6. To look more closely at the mode effects effects across modes for items, we used delta plots, which are described next.

**Delta plots.** Figure F.6 displays delta plots of items across online and paper forms. Delta is a transformed item *p*-value[8] that can be used to compare item difficulty statistics across examinee groups (Angoff & Ford, 1973) and identify items that function differently across groups. Like item statistics, delta plots can be used to identify items that show unusually high or low performance in one mode compared to other items common across modes.

Deltas are calculated by first transforming the *p*-value (item difficulty) to a normal deviate ($z$) and then scaling $z$ to a mean of 13 and a standard deviation of 4. Delta values can be plotted by group (in this case, online on one axis, paper on the other axis), and the prediction line (or delta hat) can be estimated from the observed delta values (see Angoff & Ford for details). In addition, confidence bands that indicate one and two standard errors above and below the predicted delta value can be estimated and used to indicate items that perform statistically differently across modes.

[7] For selected-response items, these statistics are commonly referred to as the item *p*-value, which is in a sample, the proportion of students answering an item correctly.
[8] See previous footnote for *p*-value explanation. For constructed-response items, item means were converted to mean proportion of points before converting to delta.

For our purposes here, we flagged items as performing differently when they fell outside of the two-standard-error band, which roughly corresponds to a 95% confidence interval. In addition, we were primarily interested in the pattern of delta values across items and the number of items flagged as performing differently across modes. Given that the number of items per form ranged from 20 to 50 (see Table F.8), we would expect to flag one to two items per plot.

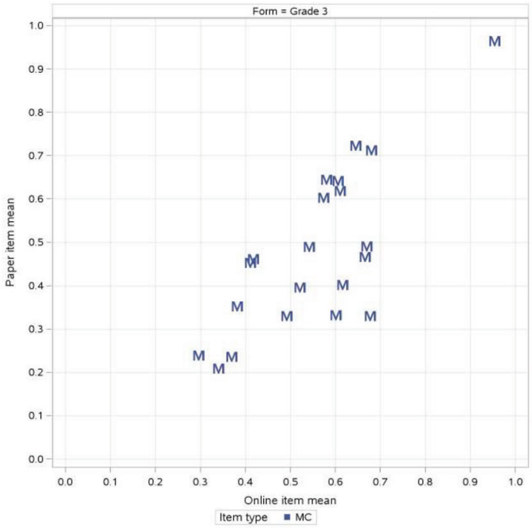
In general, all but one or two items fall within two standard errors of the predicted delta value. Forms with two items flagged were those with larger numbers of items (the number of items increases as grade increases). Therefore, almost all grades and subjects showed little evidence that items were performing differently across modes.

Delta plots for the English early high school (EHS) forms had four items that were flagged as performing differently across modes. For three of the items, the online version appeared easier, and for one of the items, the paper version appeared easier. To put these differences in perspective, Table F.13 lists the item *p*-values for the flagged English EHS items.[9] The item that appeared easier on paper was earlier in the test and the items that appeared easier online were the last three items on the test. A review of the items indicated that these items were the same except for differences due to testing mode. For the last three items on the test, it is possible that students taking the paper EHS English test were slightly more rushed than students taking the online version, and that they ran out of time at the end.

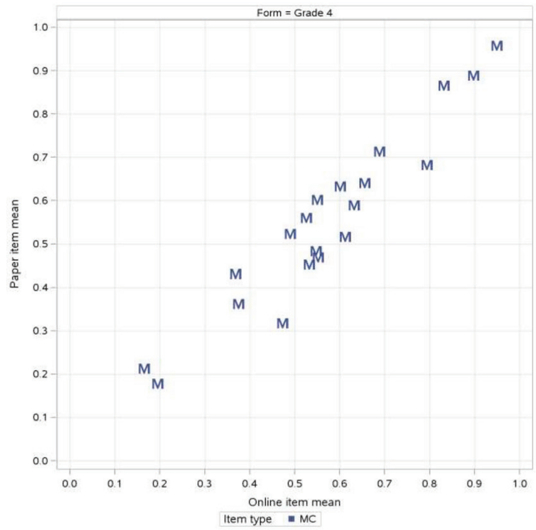
Considering the delta plot results and the results from the item statistic plots illustrates two things. First, observed differences across modes at the raw score level were not explained by specific items performing differentially better (or poorly) in one mode. In fact, with the exception of the English EHS test, few items performed differently across modes according to delta plots. Second, while it was not necessarily easy to see in the plots of item-level statistics, there did appear to be small but consistent mode effects across items for some grades and subjects, which are summarized in earlier tables comparing raw scores across modes.

[9] The values and differences of *p*-value for items that were not flagged are not included in Table F.13, but the differences between online and paper *p*-values for English EHS items that were not flagged ranged from −.10 to .10.

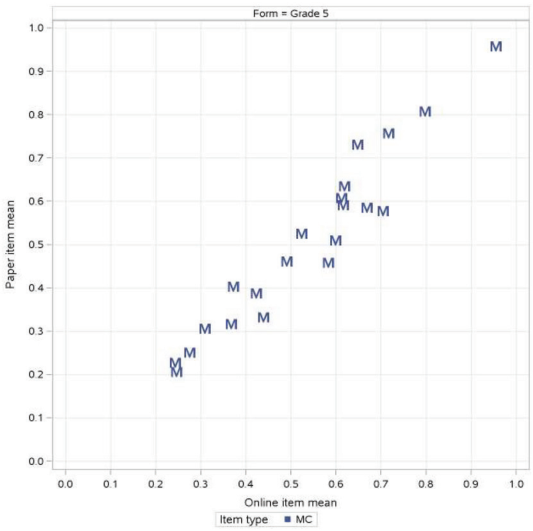
### Grade 3




### Grade 4




### Grade 5




### Grade 6

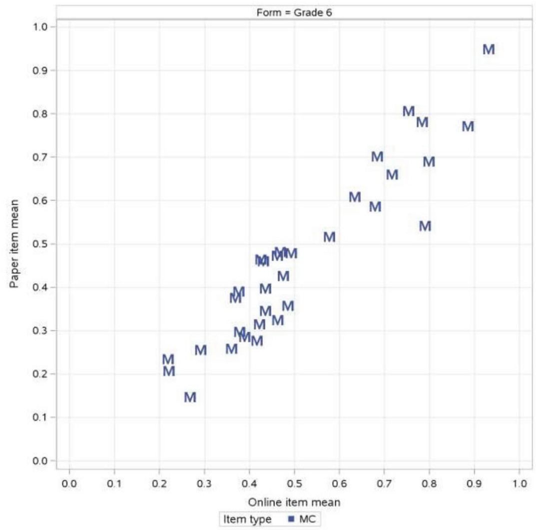
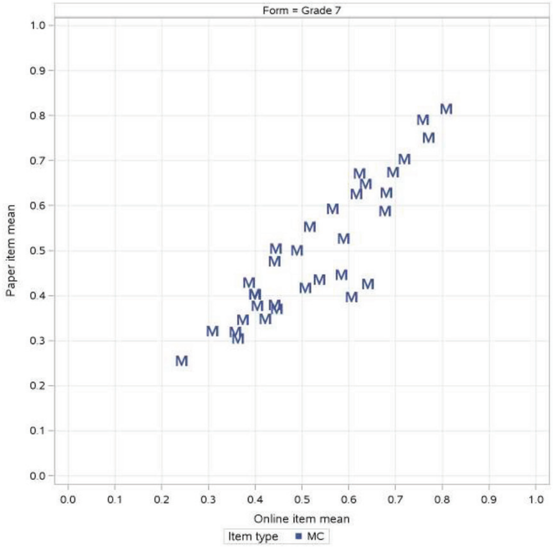


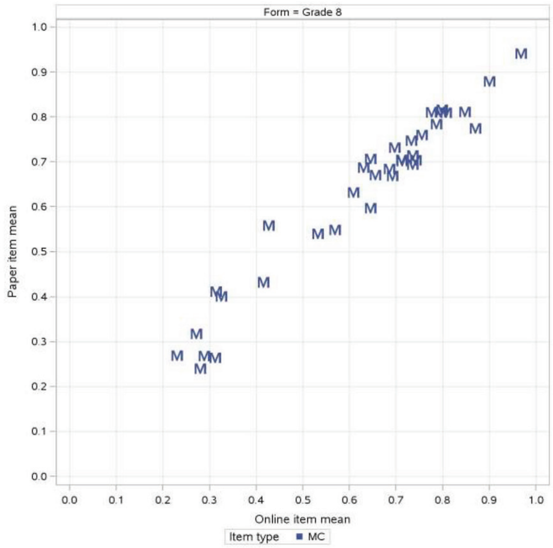

**Figure F.2. English common item mean scores for paper and online forms by item type.**

*Note*. English has only selected-response items, which are represented by an M in the figure.

### Grade 7




### Grade 8




### Early High School

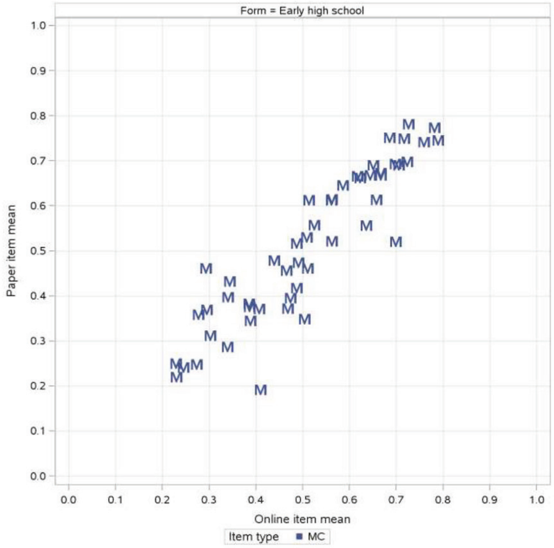
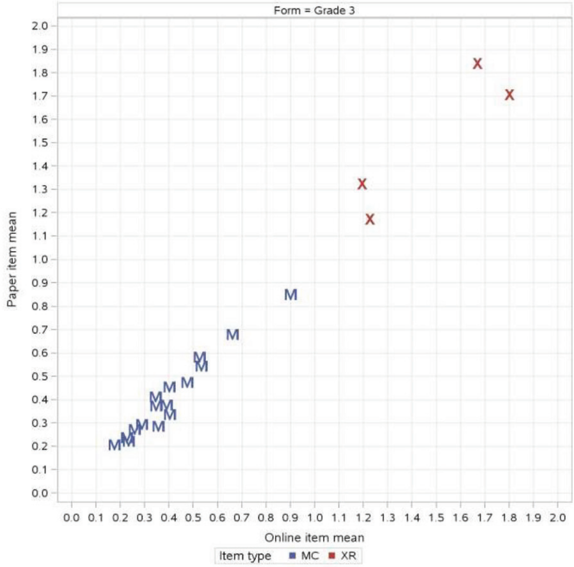


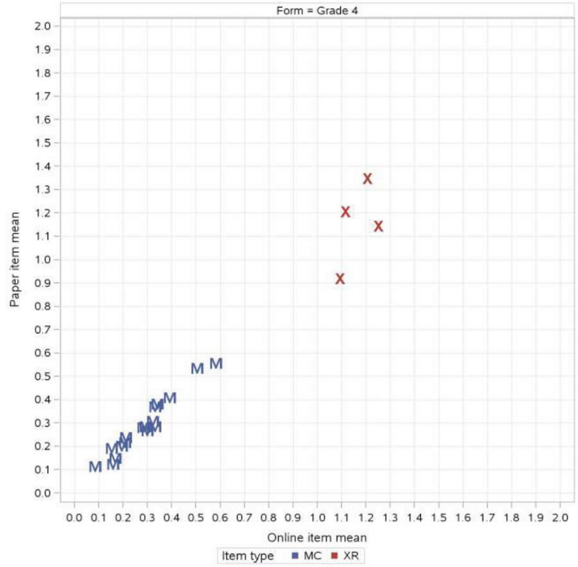

**Figure F.2. English common item mean scores for paper and online forms by item type—continued.**

*Note*. English has only selected-response items, which are represented by an M in the figure.

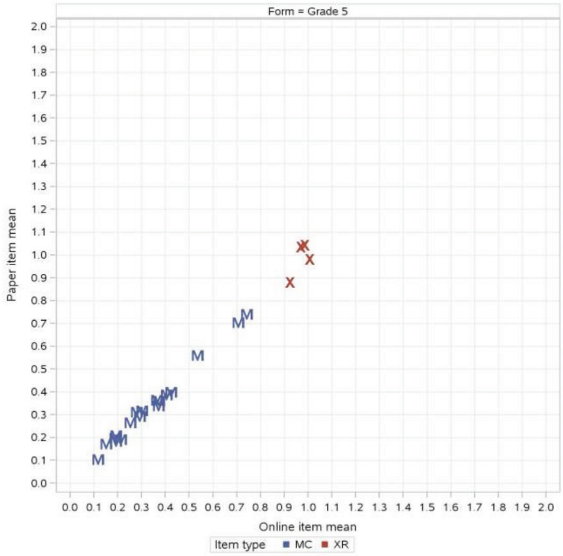
### Grade 3




### Grade 4




### Grade 5




### Grade 6

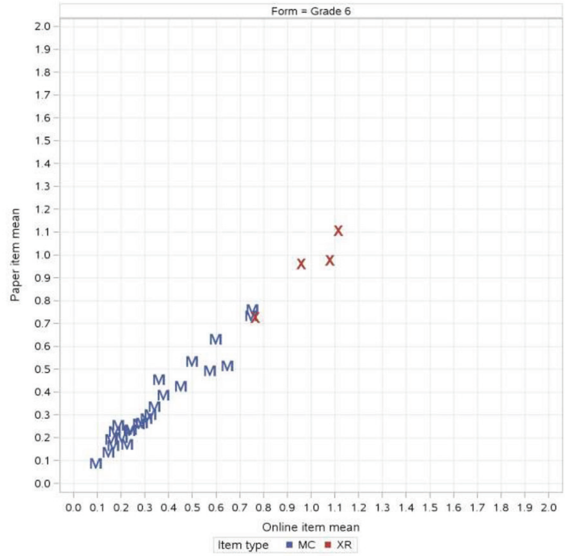
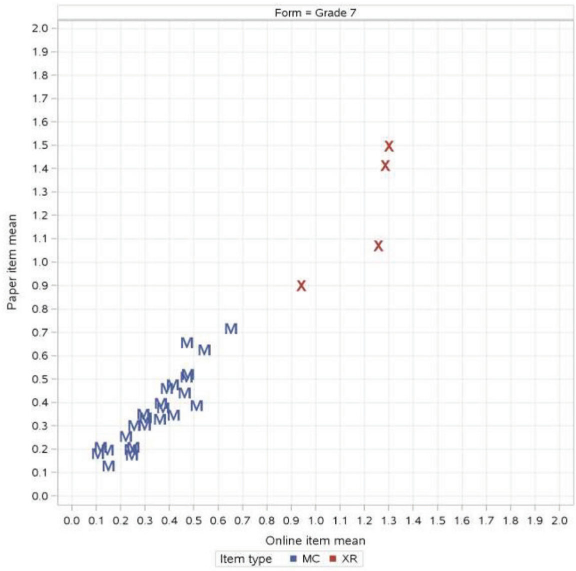


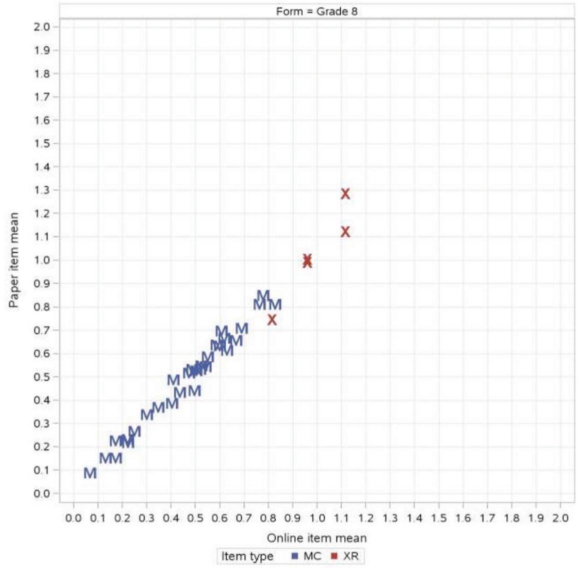

**Figure F.3. Mathematics common item mean scores for paper and online forms by item type.**

*Note*. M = selected-response item; X = constructed-response item.

### Grade 7




### Grade 8




### Early High School

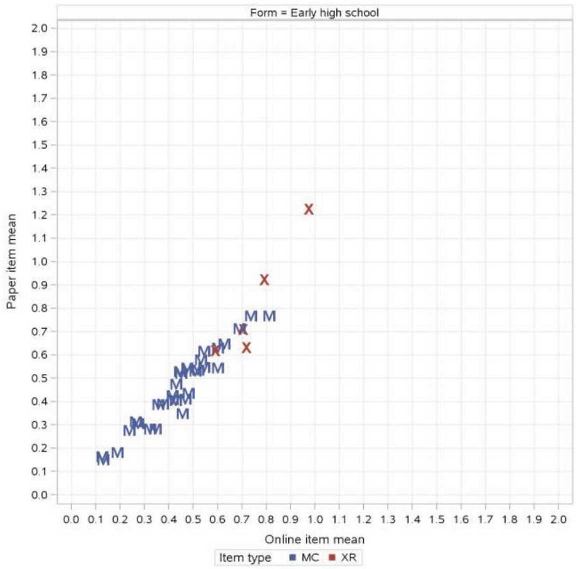
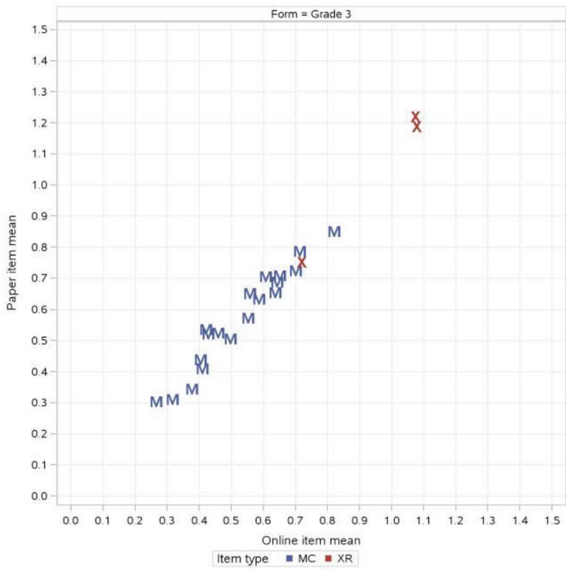


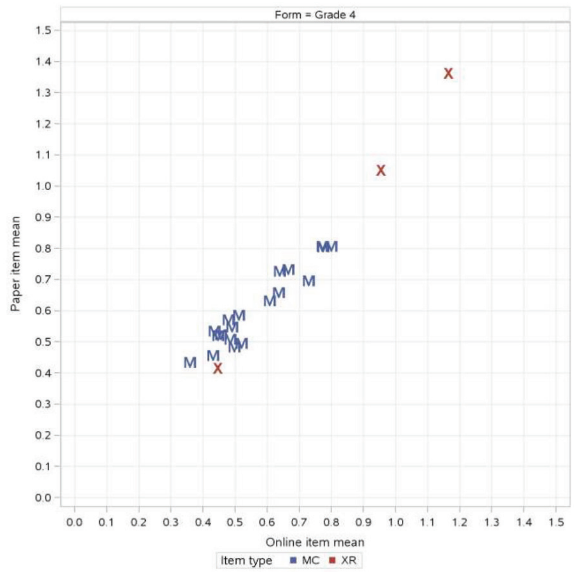

**Figure F.3. Mathematics common item mean scores for paper and online forms by item type—continued.**

*Note*. M = selected-response item; X = constructed-response item.

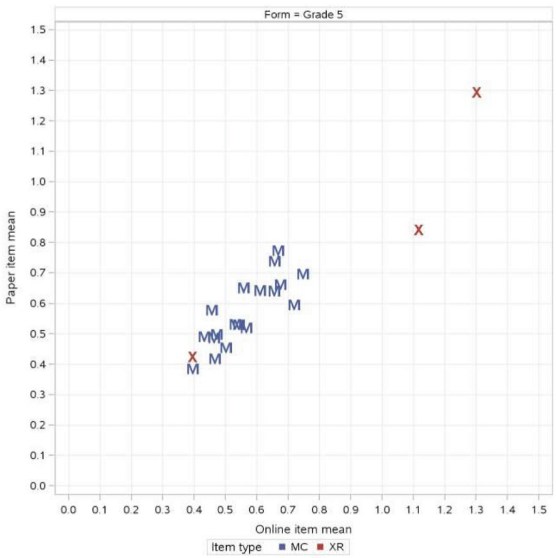
## Grade 3




## Grade 4




## Grade 5




## Grade 6

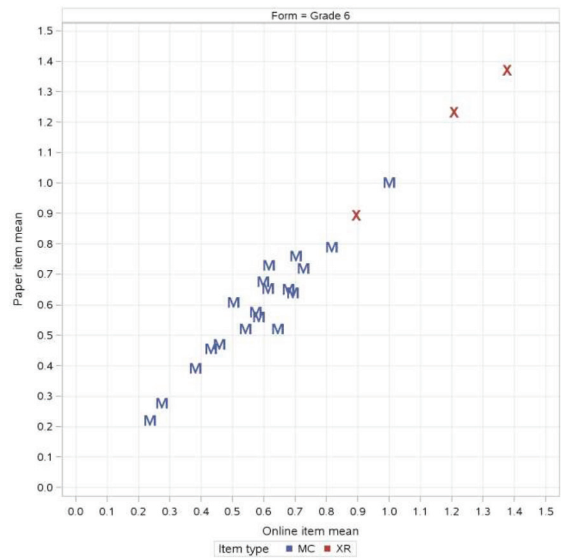
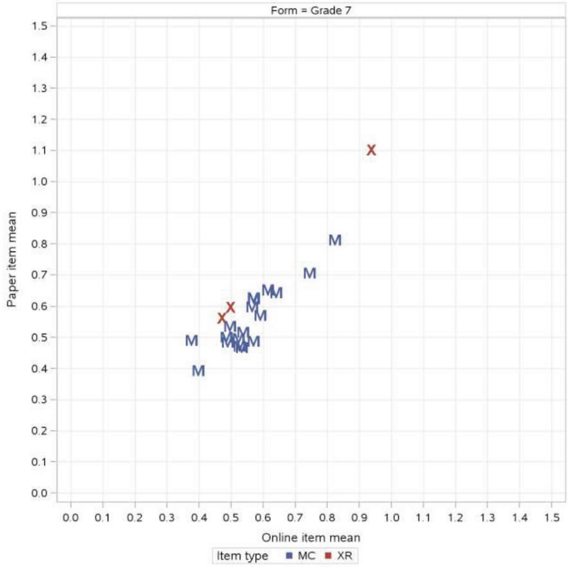


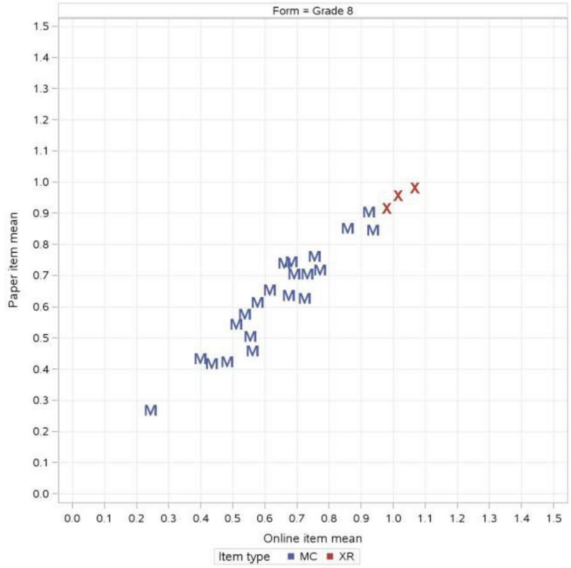

**Figure F.4. Reading common item mean scores for paper and online forms by item type.**

*Note*. M = selected-response item; X = constructed-response item.

### Grade 7




### Grade 8




### Early High School

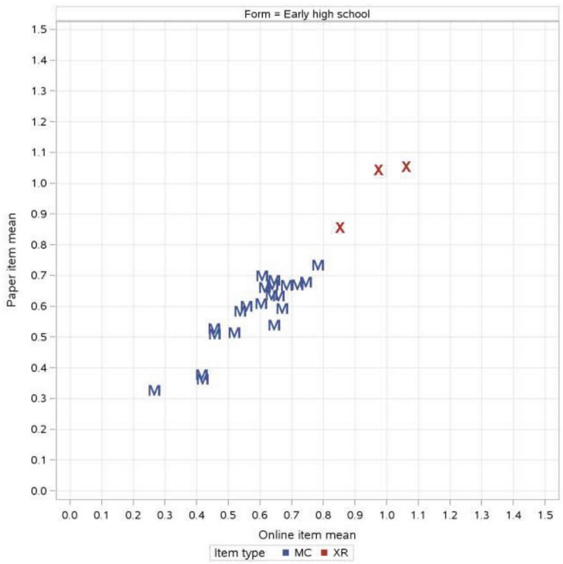
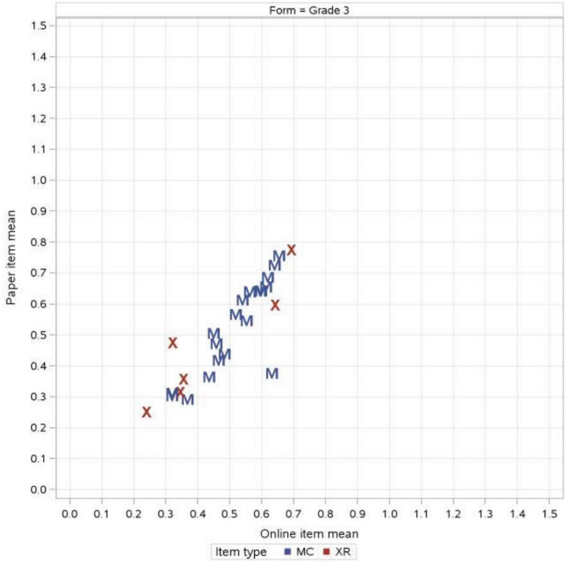



**Figure F.4. Reading common item mean scores for paper and online forms by item type—continued.**

*Note*. M = selected-response item; X = constructed-response item.

### Grade 3

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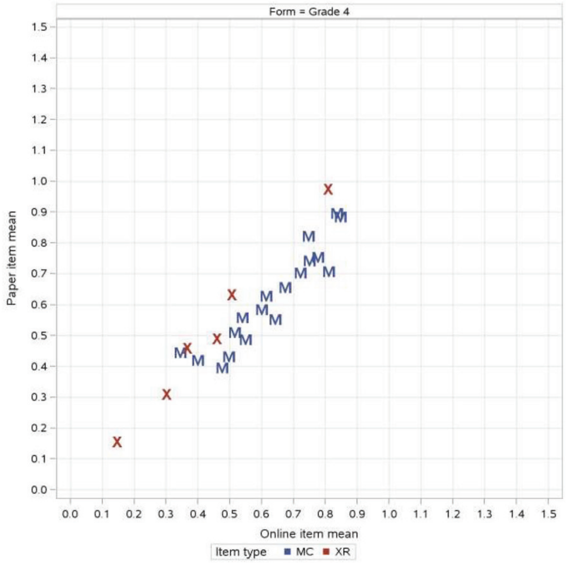
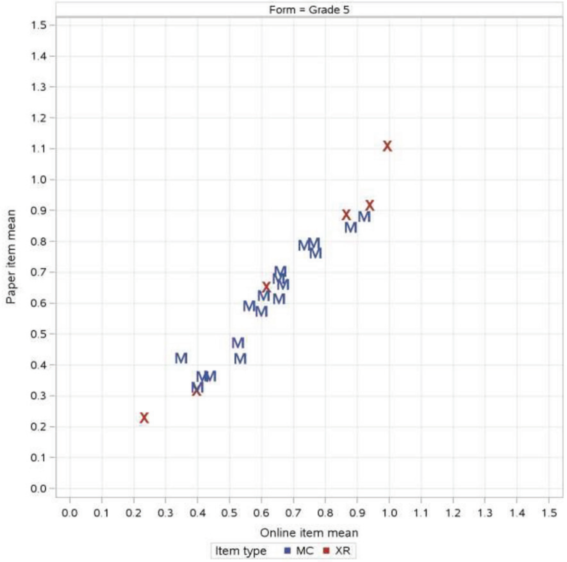



### Grade 5




### Grade 6

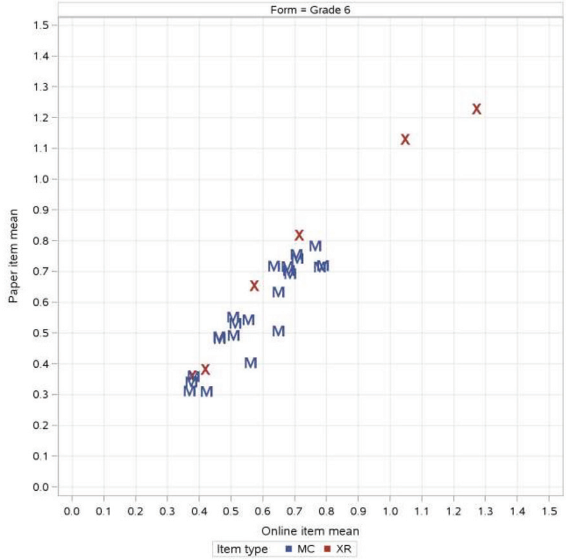
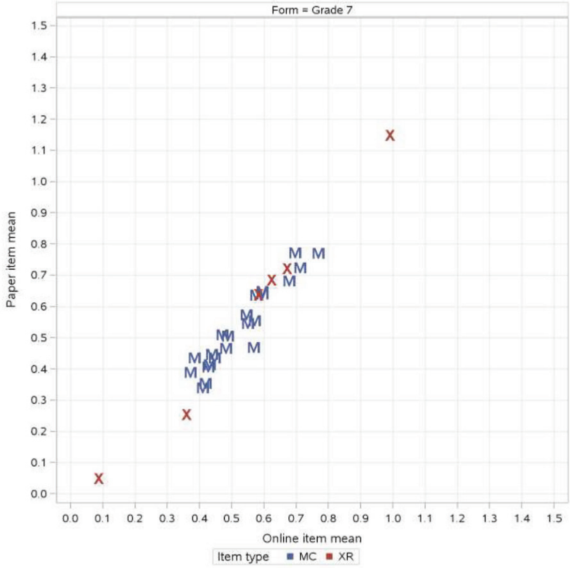


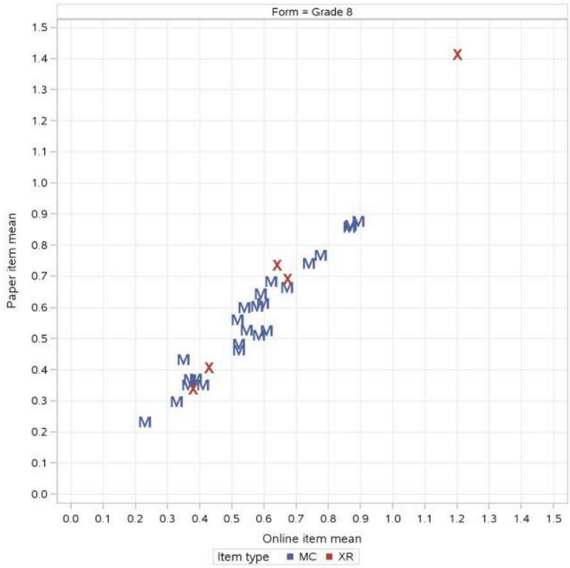

**Figure F.5. Science common item mean scores for paper and online forms by item type.**

*Note*. M = selected-response item; X = constructed-response item.

### Grade 7




### Grade 8




### Early High School

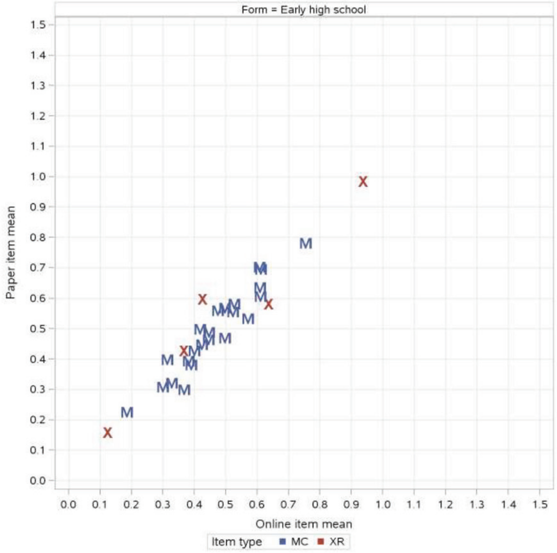
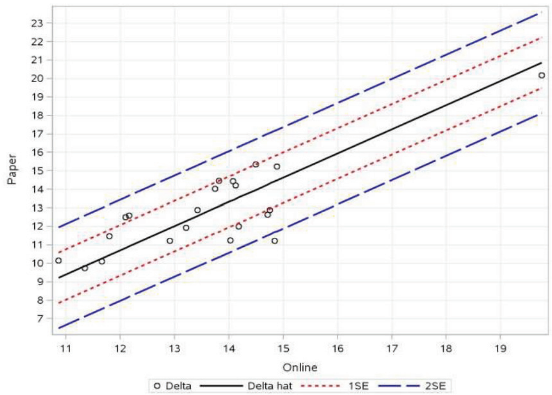


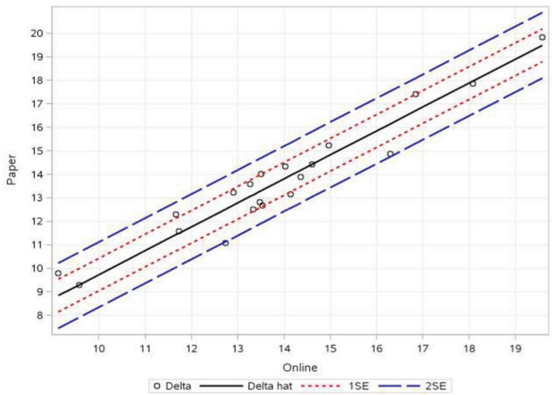

**Figure F.5. Science common item mean scores for paper and online forms by item type—continued.**

*Note*. M = selected-response item; X = constructed-response item.

### English Grade 3




### English Grade 4

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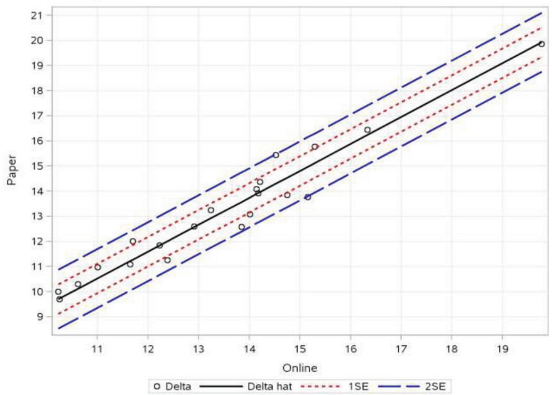


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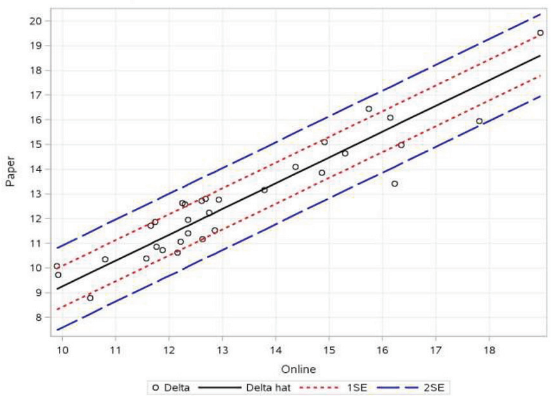
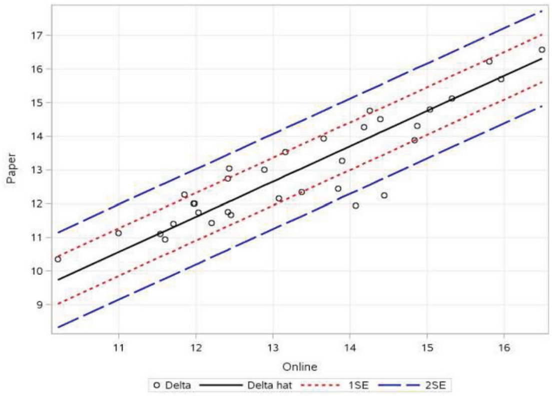
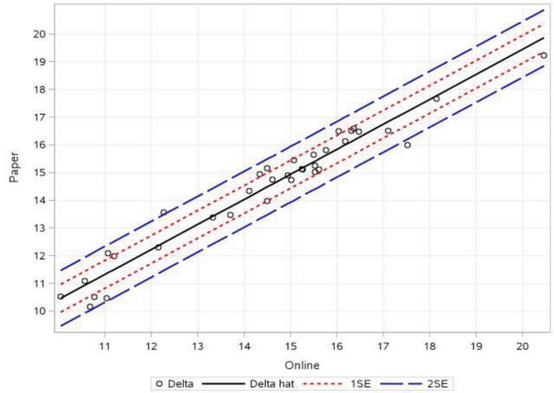



### English Grade 7

### English Grade 8




**English Early High School**

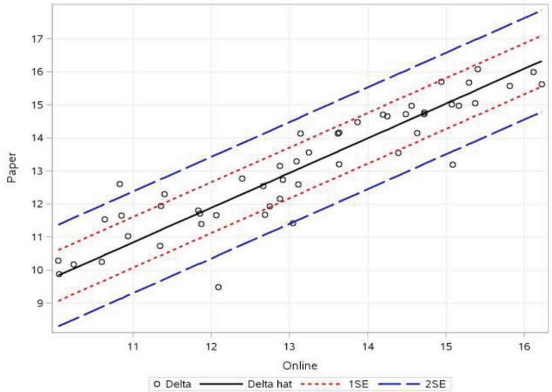
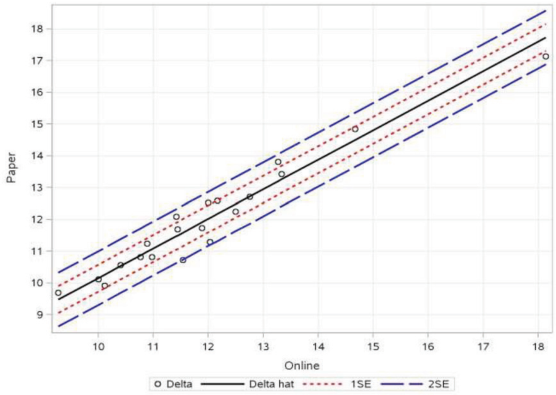
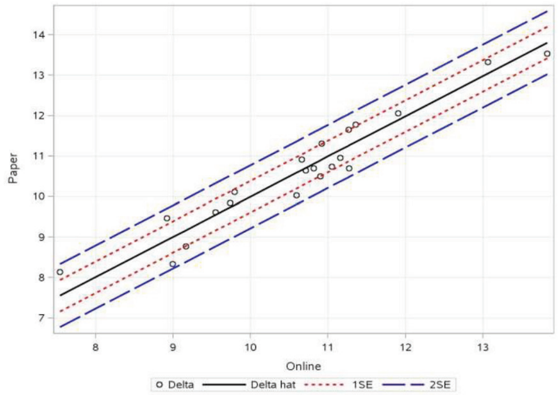



**Figure F.6. Delta plots for online and paper common items with one- and two-standard-error bands.**

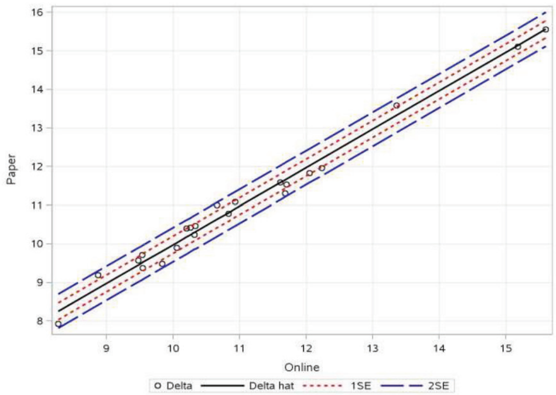
**Mathematics Grade 3**



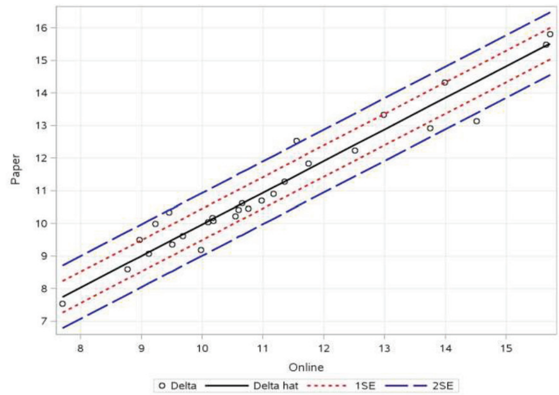

**Mathematics Grade 4**



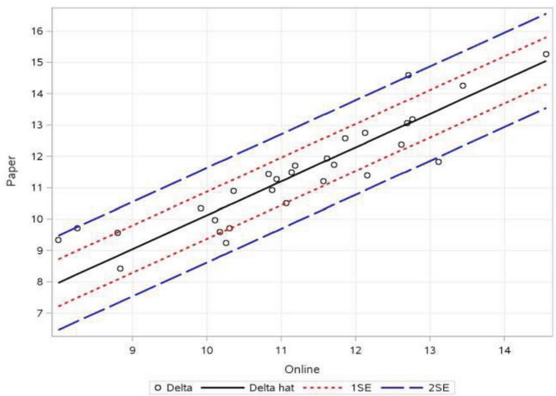

**Mathematics Grade 5**




**Mathematics Grade 6**




**Mathematics Grade 7**

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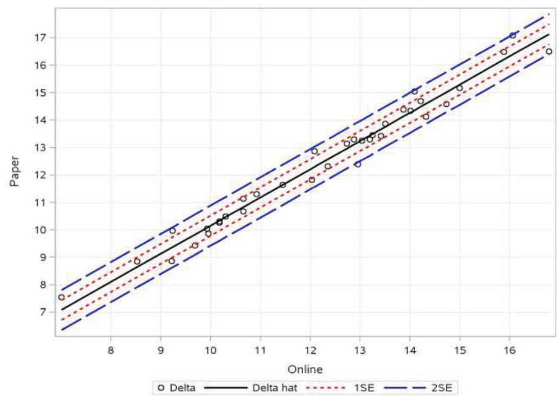



**Mathematics Early High School**

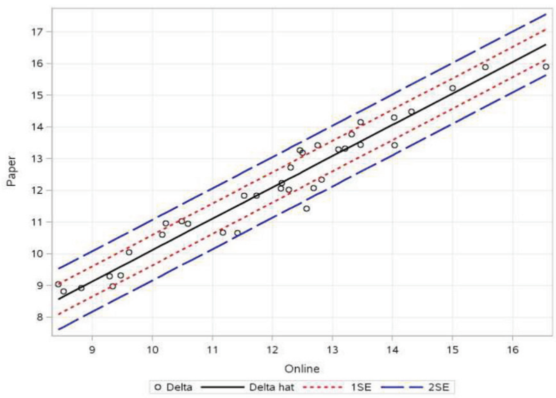
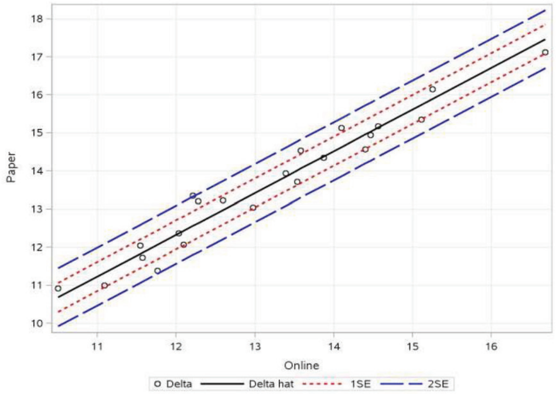
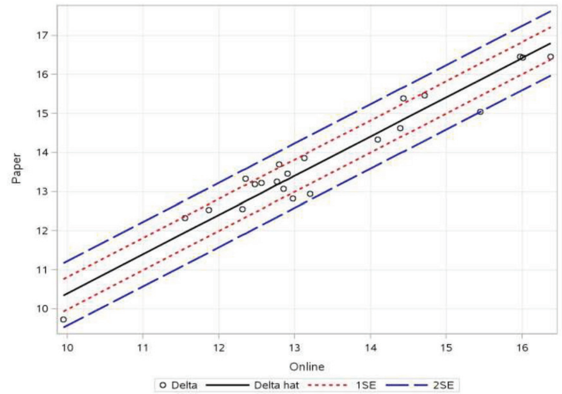



**Figure F.6. Delta plots for online and paper common items with one- and two-standard-error bands—continued.**

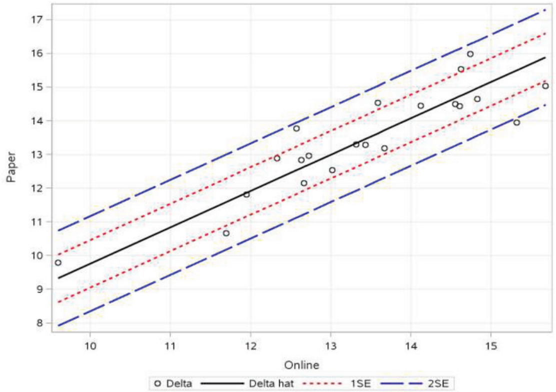
Reading Grade 3



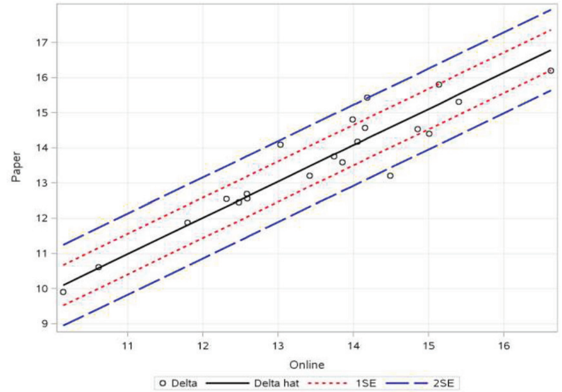

Reading Grade 4



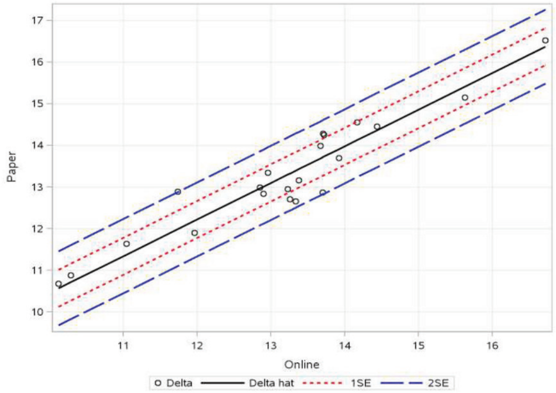

Reading Grade 5



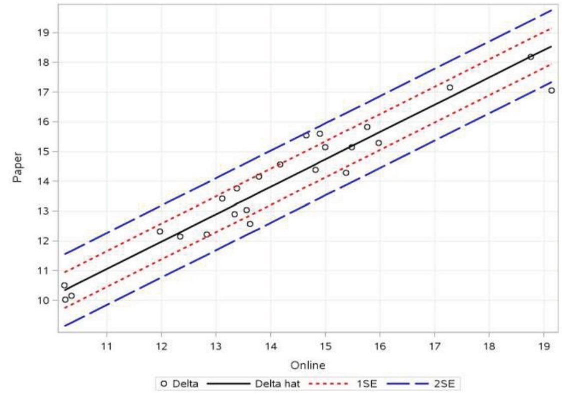

Reading Grade 6




Reading Grade 7




Reading Grade 8




Reading Early High School

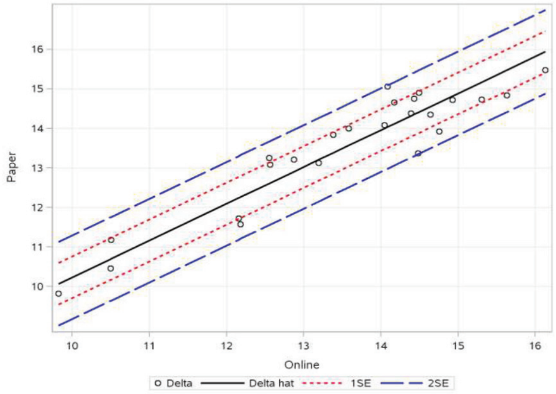
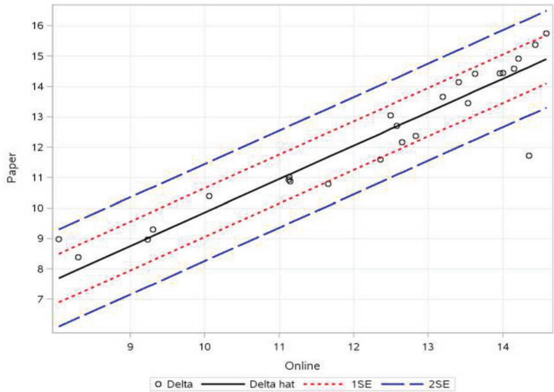
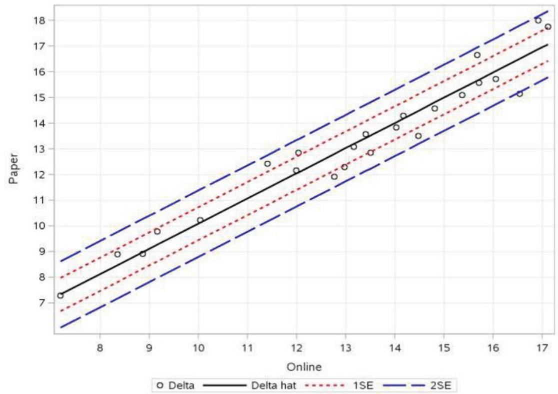



**Figure F.6. Delta plots for online and paper common items with one- and two-standard-error bands—continued.**

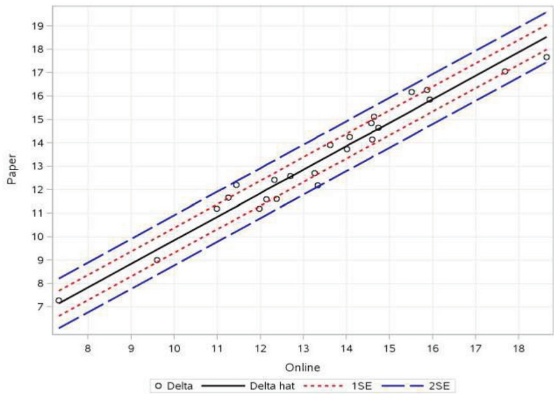
### Science Grade 3



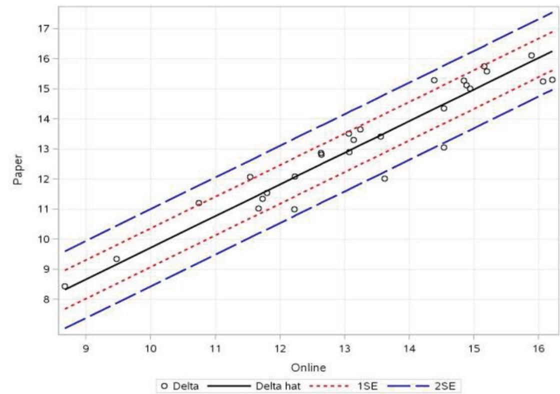

### Science Grade 4



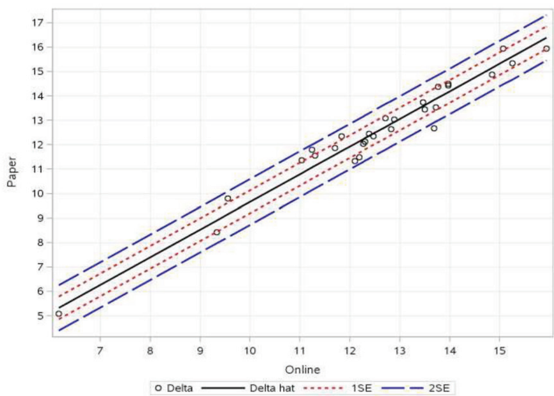

### Science Grade 5



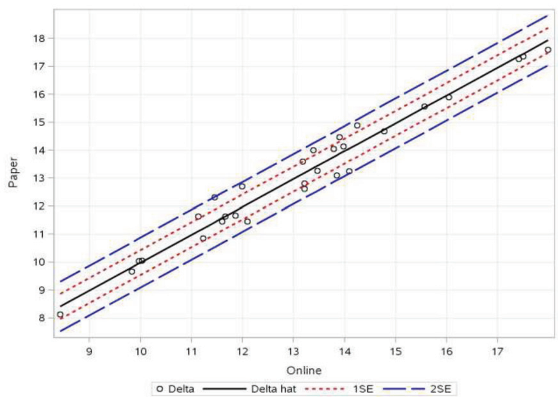

### Science Grade 6




### Science Grade 7




### Science Grade 8




### Science Early High School

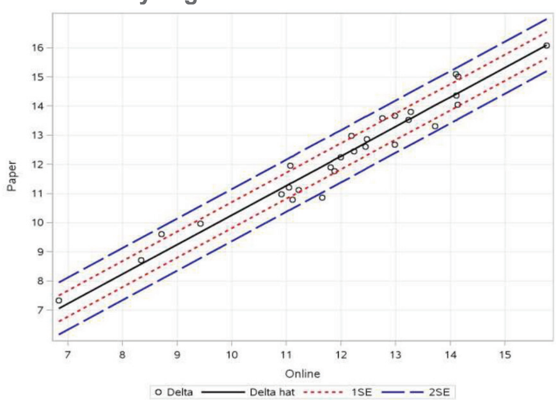



**Figure F.6. Delta plots for online and paper common items with one- and two-standard-error bands—continued.**

**Table F.13. ACT Aspire Spring 2013 Comparability Study *p*-values for English Early High School Items Flagged in Delta Plots**

| Flagged Item | Online *p*-value | Paper *p*-value | Difference (Online–Paper) |
|---|---|---|---|
| 1 | .29 | .46 | –.17 |
| 2 | .70 | .52 | .18 |
| 3 | .41 | .19 | .22 |
| 4 | .50 | .35 | .15 |

# F.6 Comparisons of Scale Scores Across Modes

We compared ACT Aspire scale scores, which were obtained after we created the score linkage between paper and online forms. Paper forms were linked to online forms using a randomly equivalent groups design with the equipercentile linking (Kolen & Brennan, 2014). The equipercentile methodology has been used extensively with other ACT testing programs, including the operational equating of ACT Aspire (see Chapter 10). The primary purpose of this particular linking was to statistically adjust for differences across forms due to item type and mode.

Tables F.14–F.18 summarize scale score statistics, including score moments (mean, standard deviation, skewness, and kurtosis), effect sizes, statistical significance tests from tests of equivalence, and the Kolmogorov-Smirnov test of difference in cumulative distributions for each subject. Figure F.7 displays the cumulative percentage of students at each scale score by mode for each subject and grade. Figure F.8 displays box plots of scale scores by mode for each subject and grade.

**Table F.14. English Scale Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of items | 25 | 25 | 25 | 25 | 25 | 25 | 35 | 35 | 35 | 35 | 35 | 35 | 50 | 50 |
| Sample size | 1,359 | 1,405 | 1,480 | 1,489 | 1,349 | 1,346 | 1,129 | 1,166 | 1,019 | 1,033 | 866 | 887 | 1,176 | 1,209 |
| Scale score | | | | | | | | | | | | | | |
| Mean | 416.32 | 416.38 | 419.64 | 419.52 | 421.79 | 421.73 | 424.23 | 424.22 | 424.74 | 424.63 | 427.61 | 427.64 | 428.23 | 428.05 |
| SD | 5.87 | 5.86 | 6.14 | 6.13 | 7.15 | 7.05 | 7.73 | 7.80 | 8.93 | 8.95 | 8.74 | 8.79 | 10.75 | 10.66 |
| Minimum | 401 | 401 | 402 | 405 | 403 | 404 | 402 | 400 | 403 | 400 | 403 | 401 | 400 | 400 |
| Maximum | 435 | 434 | 438 | 438 | 442 | 441 | 447 | 446 | 448 | 450 | 448 | 447 | 454 | 456 |
| Skewness | 0.51 | 0.49 | 0.08 | 0.11 | 0.23 | 0.25 | 0.12 | 0.12 | -0.08 | -0.07 | -0.17 | -0.17 | 0.01 | 0.01 |
| Kurtosis | -0.09 | -0.05 | -0.50 | -0.58 | -0.44 | -0.35 | -0.21 | -0.24 | -0.39 | -0.34 | -0.40 | -0.39 | -0.69 | -0.60 |
| Reliability | .79 | .79 | .76 | .79 | .80 | .79 | .82 | .81 | .83 | .82 | .84 | .80 | .90 | .90 |
| Effect size | -0.01 | | 0.02 | | 0.01 | | 0.00 | | 0.01 | | 0.00 | | 0.02 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.41 | | 1.26 | | 1.42 | | 1.11 | | 1.02 | | 0.94 | | 0.64 | |
| T-test t-statistic (df) | -0.31 (2,762) | | 0.53 (2,967) | | 0.22 (2,693) | | 0.02 (2,293) | | 0.26 (2,050) | | -0.07 (1,751) | | 0.41 (2,383) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.15. Mathematics Scale Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of items | 25 | 25 | 25 | 25 | 25 | 25 | 34 | 34 | 34 | 34 | 38 | 38 | 38 | 38 |
| Sample size | 1,488 | 1,539 | 1,534 | 1,532 | 1,450 | 1,427 | 1,156 | 1,194 | 974 | 1,010 | 896 | 927 | 1,075 | 1,098 |
| Scale score | | | | | | | | | | | | | | |
| Mean | 412.21 | 412.19 | 415.25 | 414.99 | 417.44 | 417.37 | 419.85 | 419.87 | 419.73 | 420.03 | 422.92 | 422.65 | 424.88 | 425.11 |
| SD | 3.96 | 4.04 | 4.15 | 4.18 | 4.83 | 4.75 | 5.69 | 5.68 | 6.53 | 6.67 | 7.92 | 7.90 | 8.65 | 8.73 |
| Minimum | 400 | 400 | 403 | 402 | 404 | 403 | 404 | 404 | 404 | 403 | 401 | 403 | 408 | 405 |
| Maximum | 425 | 427 | 430 | 433 | 438 | 435 | 445 | 442 | 443 | 442 | 445 | 444 | 451 | 451 |
| Skewness | 0.06 | -0.04 | 0.09 | 0.19 | 0.53 | 0.39 | 0.45 | 0.40 | 0.46 | 0.39 | 0.24 | 0.32 | 0.42 | 0.35 |
| Kurtosis | -0.02 | -0.03 | 0.26 | 0.58 | 0.58 | 0.36 | 0.27 | 0.20 | 0.08 | 0.02 | -0.37 | -0.41 | -0.50 | -0.56 |
| Reliability | .79 | .77 | .68 | .66 | .70 | .69 | .78 | .77 | .84 | .83 | .89 | .88 | .89 | .88 |
| Effect size | 0.00 | | 0.06 | | 0.02 | | 0.00 | | -0.05 | | 0.03 | | -0.03 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.59* | | 2.49* | | 1.95* | | 1.50* | | 0.98 | | 0.92 | | 1.03 | |
| T-test t-statistic (df) | 0.12 (3,025) | | 1.71 (3,064) | | 0.43 (2,875) | | -0.07 (2,348) | | -1.02 (1,982) | | 0.73 (1,821) | | -0.61 (2,171) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.16. Reading Scale Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of items | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| Sample size | 1,441 | 1,513 | 1,399 | 1,401 | 1,299 | 1,294 | 1,004 | 1,038 | 1,010 | 1,037 | 800 | 831 | 857 | 919 |
| Scale score | | | | | | | | | | | | | | |
| Mean | 411.84 | 411.78 | 414.35 | 414.37 | 416.27 | 416.38 | 418.15 | 418.19 | 419.09 | 419.07 | 421.18 | 421.07 | 421.48 | 421.51 |
| SD | 5.28 | 5.22 | 5.56 | 5.62 | 6.29 | 6.10 | 6.68 | 6.65 | 6.93 | 6.86 | 7.49 | 7.55 | 7.87 | 7.89 |
| Minimum | 401 | 401 | 402 | 401 | 401 | 401 | 403 | 402 | 402 | 402 | 401 | 402 | 403 | 403 |
| Maximum | 427 | 429 | 431 | 431 | 434 | 433 | 436 | 436 | 438 | 436 | 437 | 440 | 440 | 442 |
| Skewness | 0.42 | 0.39 | 0.26 | 0.27 | 0.23 | 0.28 | 0.05 | 0.04 | 0.04 | 0.03 | -0.05 | -0.05 | -0.01 | 0.02 |
| Kurtosis | -0.49 | -0.50 | -0.59 | -0.56 | -0.57 | -0.52 | -0.68 | -0.67 | -0.68 | -0.71 | -0.80 | -0.78 | -0.90 | -0.89 |
| Reliability | .85 | .84 | .84 | .84 | .84 | .83 | .84 | .82 | .83 | .83 | .85 | .85 | .88 | .88 |
| Effect size | 0.01 | | 0.00 | | -0.02 | | -0.01 | | 0.00 | | 0.01 | | 0.00 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.07 | | 1.03 | | 0.76 | | 1.15 | | 0.90 | | 1.03 | | 0.64 | |
| T-test t-statistic (df) | 0.27 (2,952) | | -0.11 (2,798) | | -0.46 (2,591) | | -0.15 (2,040) | | 0.07 (2,045) | | 0.28 (1,629) | | -0.07 (1,774) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.17. Science Scale Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of items | 28 | 28 | 28 | 28 | 28 | 28 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Sample size | 1,376 | 1,405 | 1,435 | 1,444 | 1,378 | 1,379 | 1,047 | 1,040 | 1,028 | 1,042 | 913 | 934 | 959 | 1,023 |
| Scale score | | | | | | | | | | | | | | |
| Mean | 413.60 | 413.59 | 417.02 | 417.09 | 418.98 | 418.83 | 419.69 | 419.71 | 419.70 | 419.74 | 422.97 | 422.80 | 424.49 | 424.64 |
| SD | 5.94 | 5.93 | 6.59 | 6.69 | 6.55 | 6.66 | 7.15 | 7.04 | 8.04 | 8.03 | 7.90 | 7.87 | 8.15 | 8.09 |
| Minimum | 401 | 401 | 401 | 400 | 402 | 401 | 403 | 401 | 401 | 402 | 403 | 403 | 405 | 404 |
| Maximum | 431 | 432 | 434 | 435 | 438 | 435 | 438 | 439 | 441 | 438 | 444 | 444 | 447 | 449 |
| Skewness | 0.32 | 0.40 | 0.07 | 0.02 | -0.10 | -0.10 | 0.07 | 0.10 | 0.17 | 0.16 | -0.06 | -0.02 | 0.17 | 0.17 |
| Kurtosis | -0.60 | -0.50 | -0.55 | -0.77 | -0.48 | -0.68 | -0.65 | -0.55 | -0.89 | -0.93 | -0.67 | -0.70 | -0.69 | -0.58 |
| Reliability | .89 | .88 | .85 | .85 | .86 | .87 | .89 | .88 | .90 | .89 | .88 | .88 | .86 | .87 |
| Effect size | 0.00 | | -0.01 | | 0.02 | | 0.00 | | 0.00 | | 0.02 | | -0.02 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.16 | | 1.19 | | 0.79 | | 0.81 | | 0.55 | | 0.86 | | 0.94 | |
| T-test t-statistic (df) | 0.04 (2,779) | | -0.28 (2,877) | | 0.61 (2,755) | | -0.07 (2,085) | | -0.11 (2,068) | | 0.46 (1,845) | | -0.41 (1,980) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

**Table F.18. Writing Scale Score Summary for Online and Paper Modes**

| | Grade | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | EHS | |
| | O | P | O | P | O | P | O | P | O | P | O | P | O | P |
| Number of items | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Sample size | 1,236 | 1,295 | 1,272 | 1,289 | 1,106 | 1,106 | 847 | 888 | 834 | 839 | 646 | 665 | 708 | 777 |
| Scale score | | | | | | | | | | | | | | |
| Mean | 422.20 | 422.19 | 422.35 | 422.47 | 422.87 | 422.88 | 427.10 | 427.04 | 424.76 | 424.76 | 424.36 | 424.37 | 424.75 | 424.75 |
| SD | 7.06 | 6.91 | 7.12 | 6.87 | 7.48 | 7.45 | 7.90 | 7.61 | 7.74 | 7.73 | 6.99 | 7.03 | 7.31 | 7.29 |
| Minimum | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 | 408 |
| Maximum | 440 | 440 | 440 | 440 | 440 | 440 | 446 | 448 | 448 | 448 | 446 | 448 | 448 | 448 |
| Skewness | 0.21 | 0.23 | -0.07 | -0.05 | 0.08 | 0.06 | -0.14 | -0.06 | 0.27 | 0.28 | -0.20 | -0.14 | 0.02 | 0.06 |
| Kurtosis | -0.37 | -0.34 | -0.52 | -0.40 | -0.28 | -0.33 | -0.32 | -0.32 | 0.09 | -0.01 | -0.20 | -0.17 | 0.12 | 0.13 |
| Reliability | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Effect size | 0.00 | | -0.02 | | 0.00 | | 0.01 | | 0.00 | | 0.00 | | 0.00 | |
| Stat. test | | | | | | | | | | | | | | |
| Kolmogorov-Smirnov test | 1.70* | | 3.77* | | 1.83* | | 3.76* | | 1.88* | | 1.57* | | 1.22 | |
| T-test t-statistic (df) | 0.05 (2,455) | | -0.42 (2,538) | | -0.02 (2,201) | | 0.16 (1,723) | | -0.01 (1,659) | | -0.04 (1,301) | | 0.00 (1,463) | |

*Note*. O = online form; P = paper form.
* Statistically significant at .05.

Compared to Tables F.8–F.12, which contained raw scores on common items across modes, we see that differences in scale scores are small and generally not statistically significant. For example, if we compare the grade 3 English raw score cumulative distributions in Figure F.1 to the grade 3 English scale score cumulative distributions in Figure F.7, we see that the cumulative score differences are small or negligible for the scale scores. While the score differences across modes were eliminated for most of the statistics in Tables F.14–F.18, there were some cases where the Kolmogorov-Smirnov test indicated statistical differences in the cumulative distributions between modes in mathematics and writing. However, these differences appeared to be small, as illustrated by Figure F.7, and effect sizes were near zero. The box plots in Figure F.8 further illustrate scale score comparability across modes. The box plots are not identical across modes for each grade, but they do appear similar in most cases, which is indicative of similar score distributions across modes.

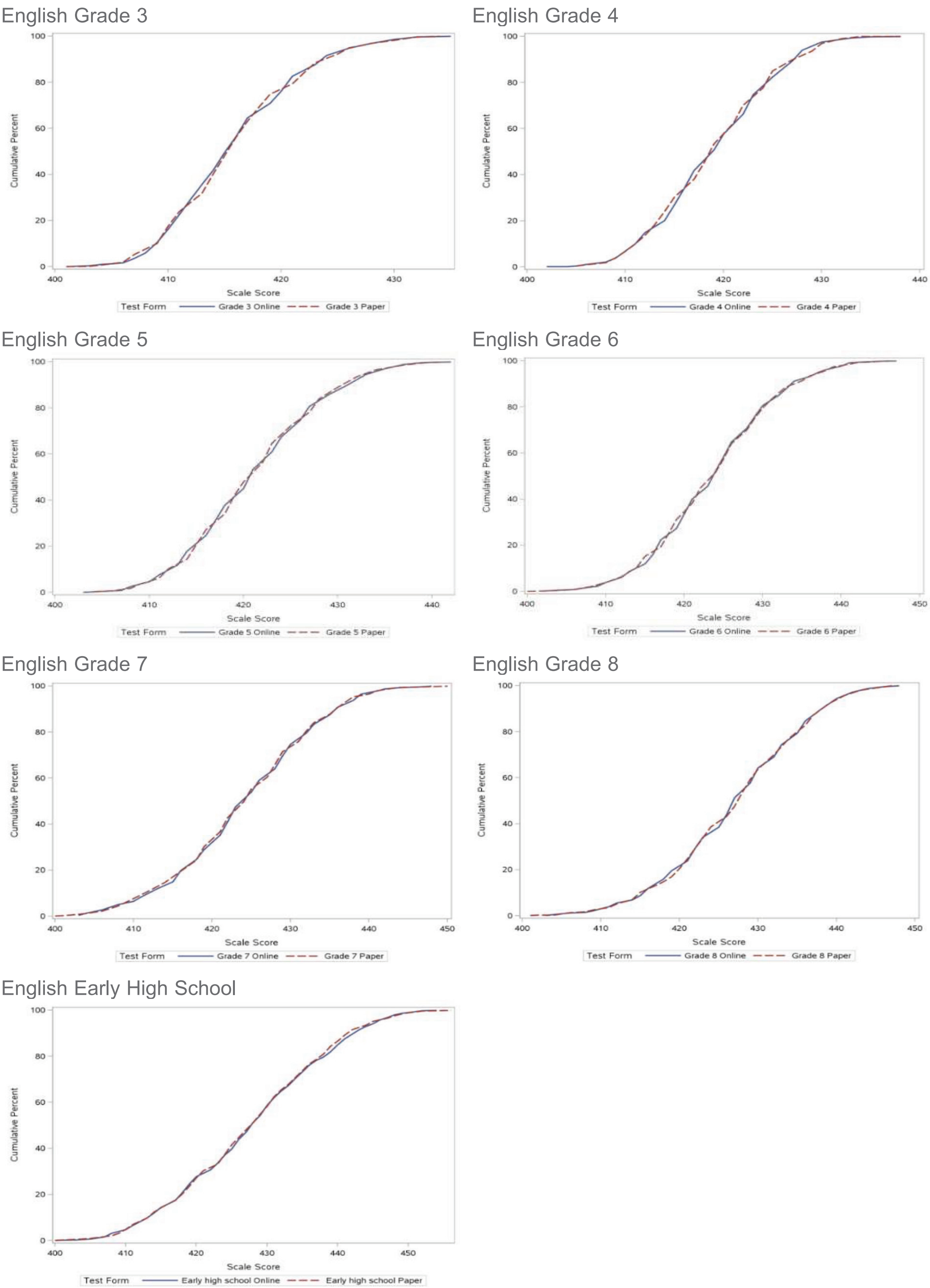
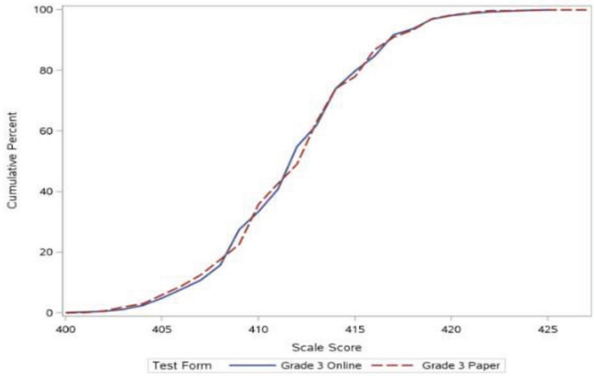
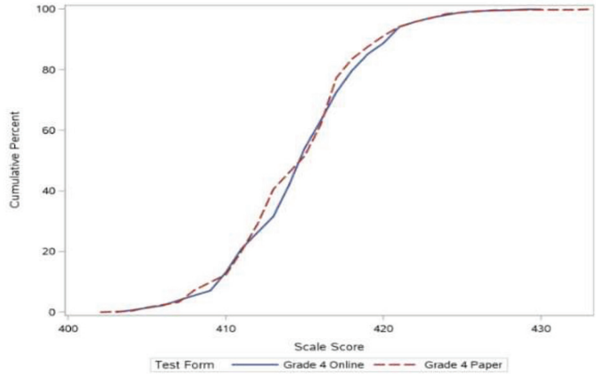



**Figure F.7. Cumulative percentage of students for scale score across modes.**

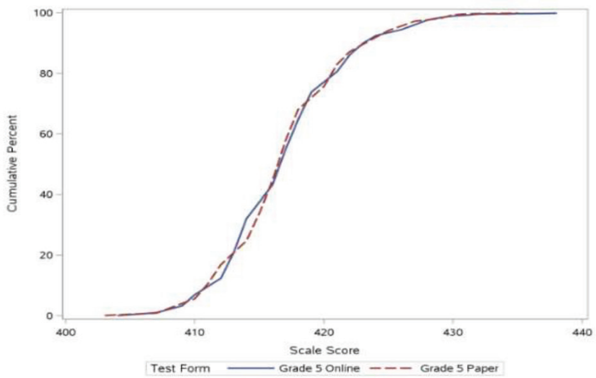
Mathematics Grade 3



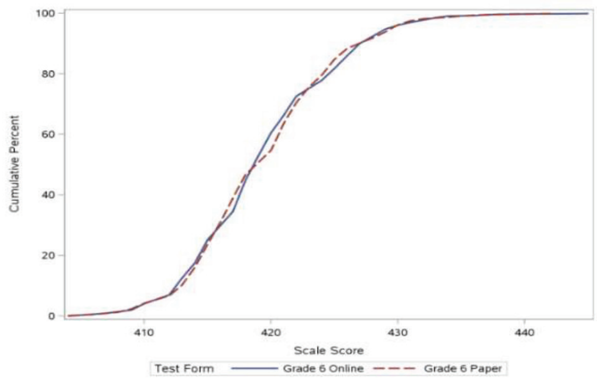

Mathematics Grade 4



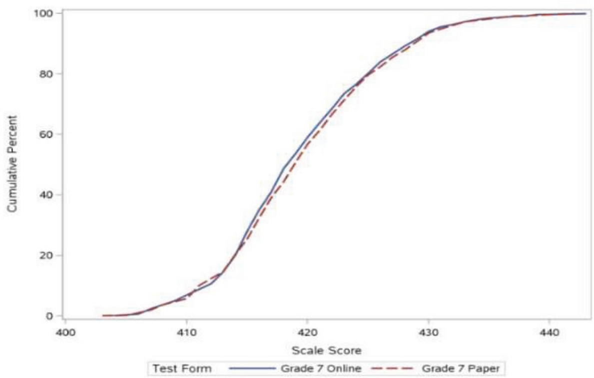

Mathematics Grade 5



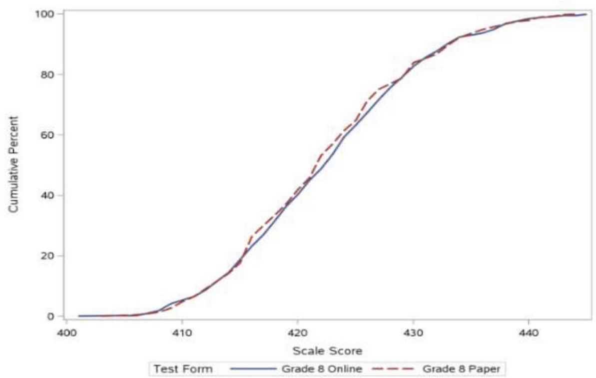

Mathematics Grade 6




Mathematics Grade 7




Mathematics Grade 8




Mathematics Early High School

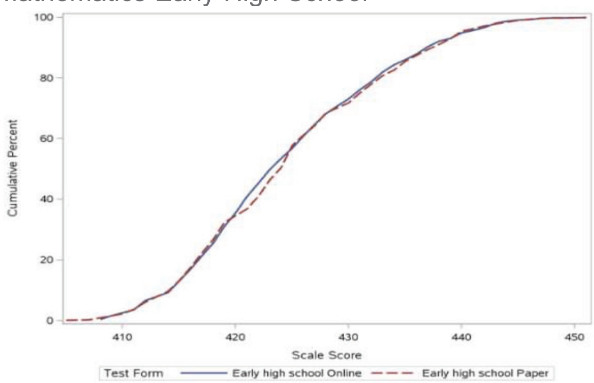
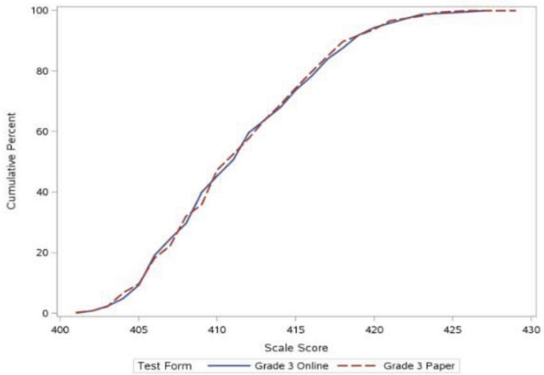
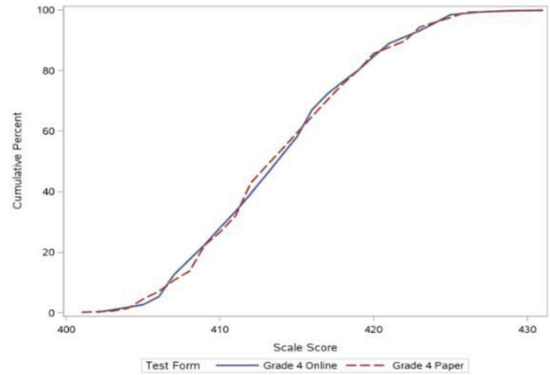



**Figure F.7. Cumulative percentage of students for scale score across modes—continued.**

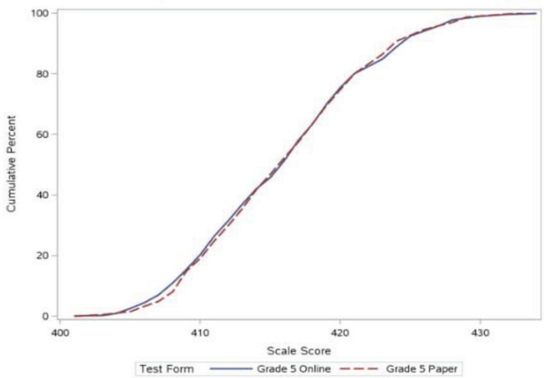
Reading Grade 3



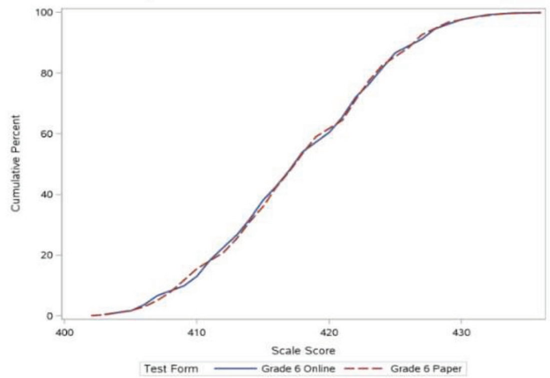

Reading Grade 4



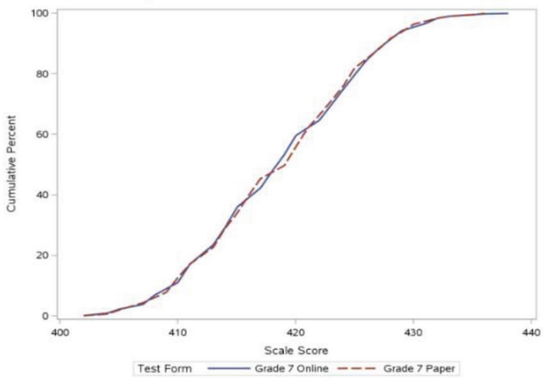

Reading Grade 5



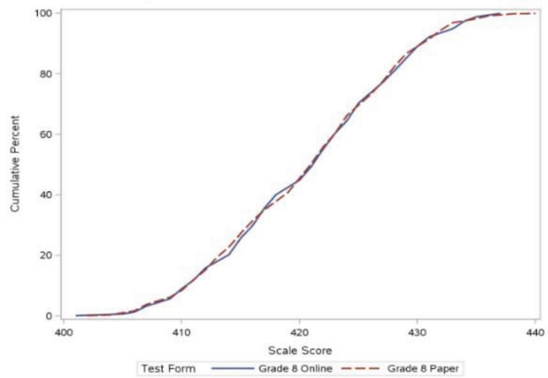

Reading Grade 6




Reading Grade 7




Reading Grade 8




Reading Early High School

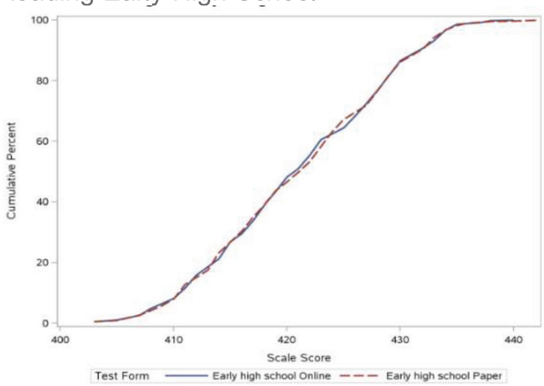
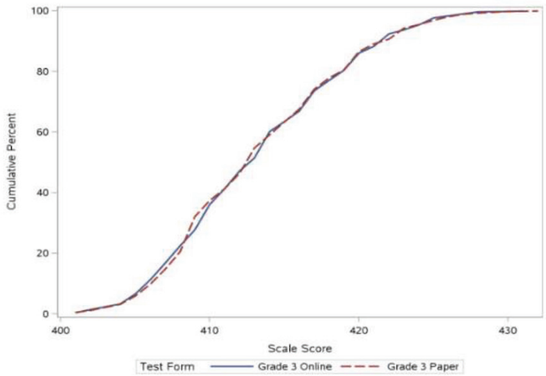
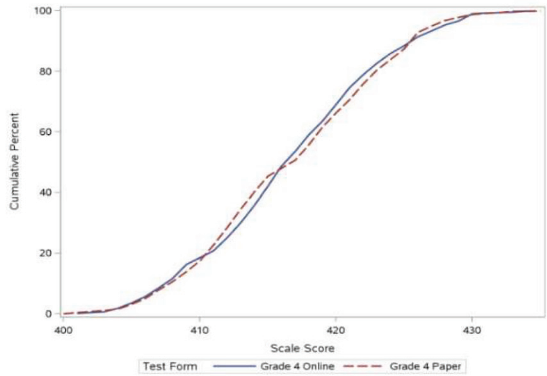



**Figure F.7. Cumulative percentage of students for scale score across modes—continued.**

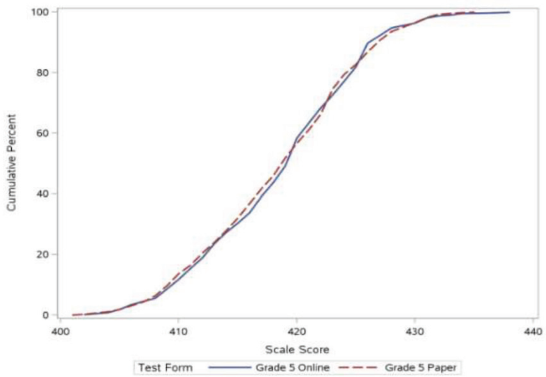
Science Grade 3



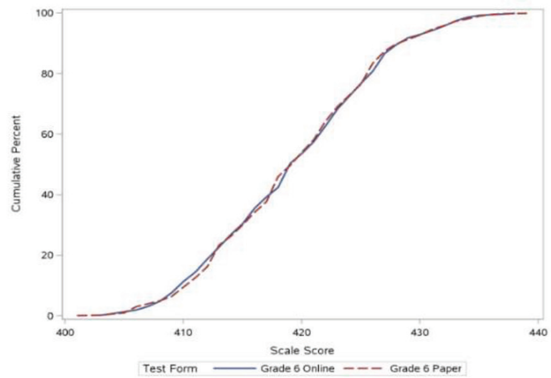

Science Grade 4



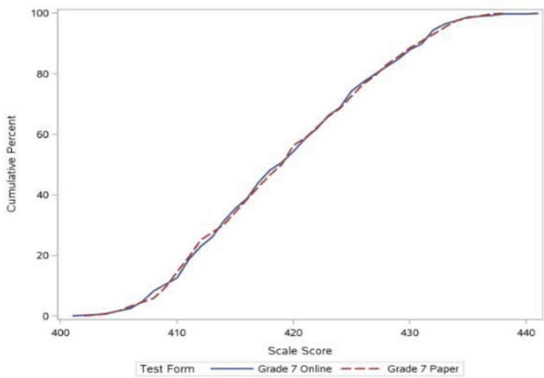

Science Grade 5



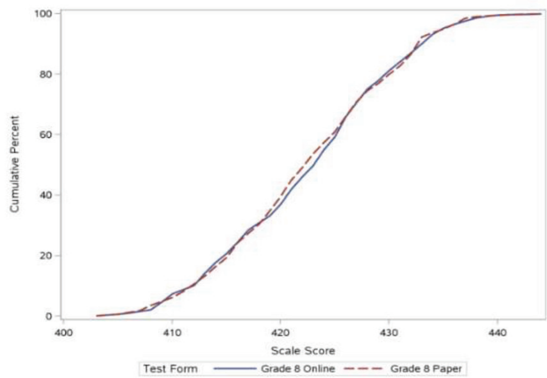

Science Grade 6




Science Grade 7




Science Grade 8




Science Early High School

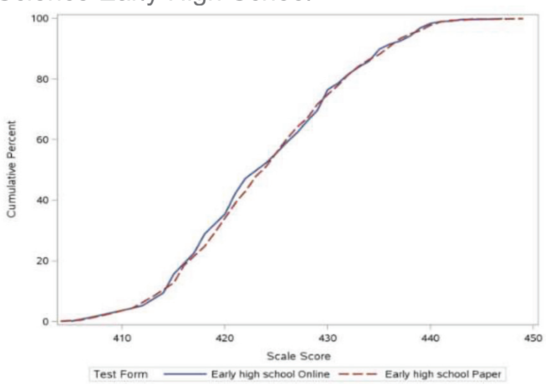
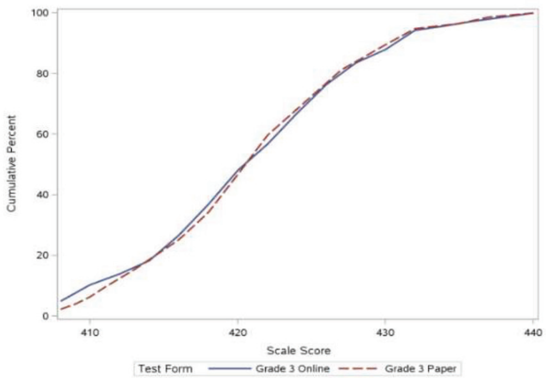
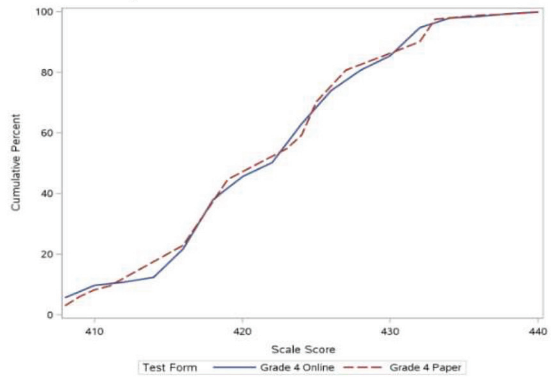



**Figure F.7. Cumulative percentage of students for scale score across modes—continued.**

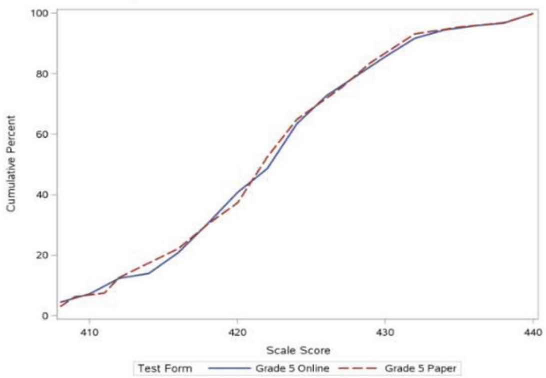
Writing Grade 3



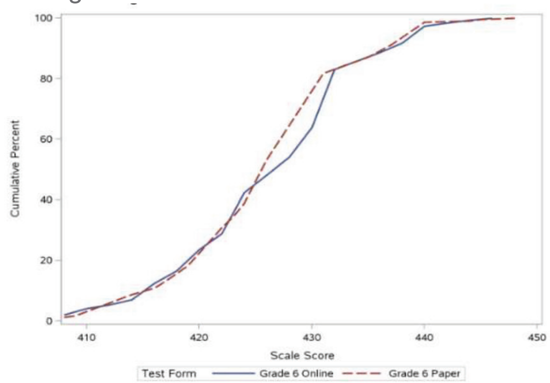

Writing Grade 4



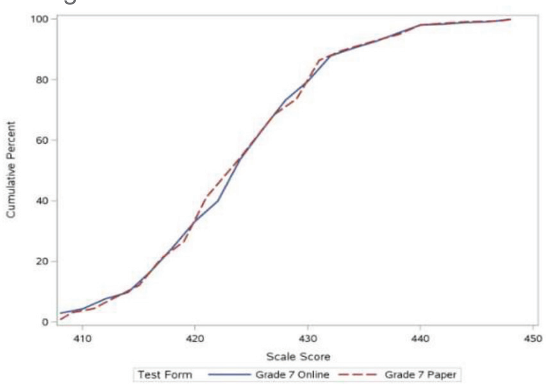

Writing Grade 5



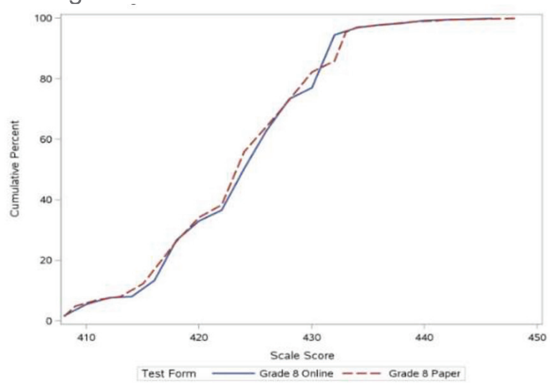

Writing Grade 6




Writing Grade 7




Writing Grade 8




Writing Early High School

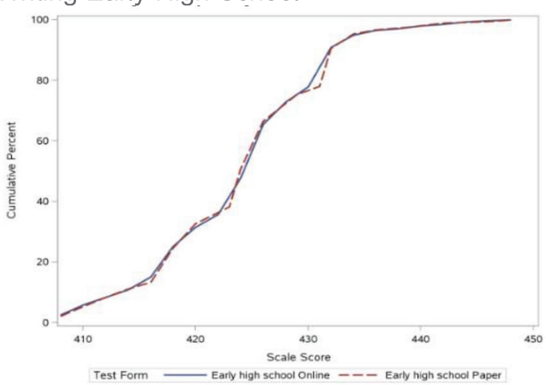
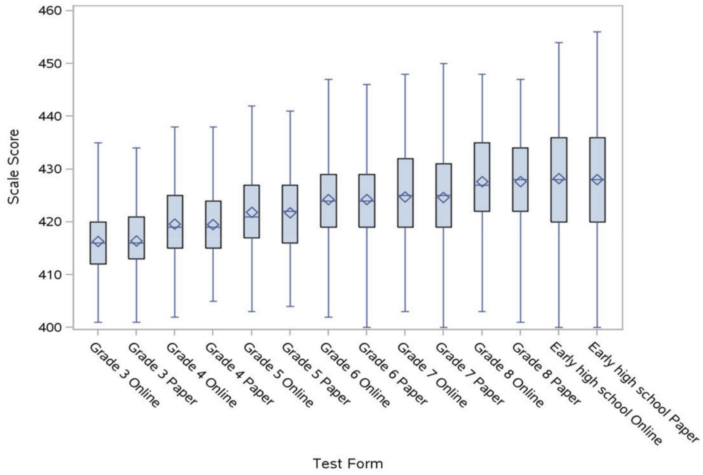
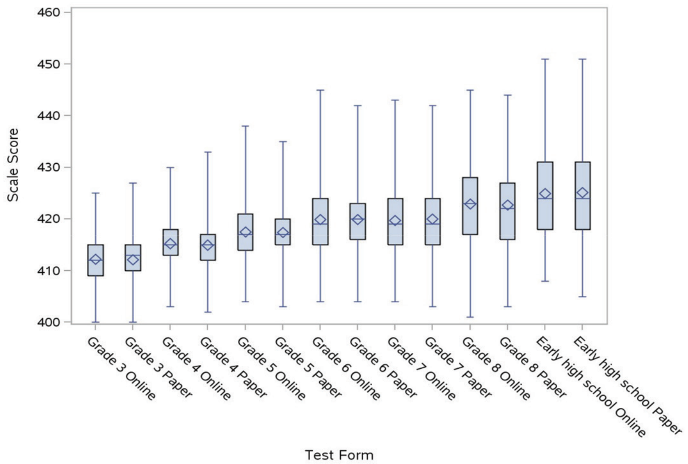



**Figure F.7. Cumulative percentage of students for scale score across modes—continued.**

English




Mathematics




Reading

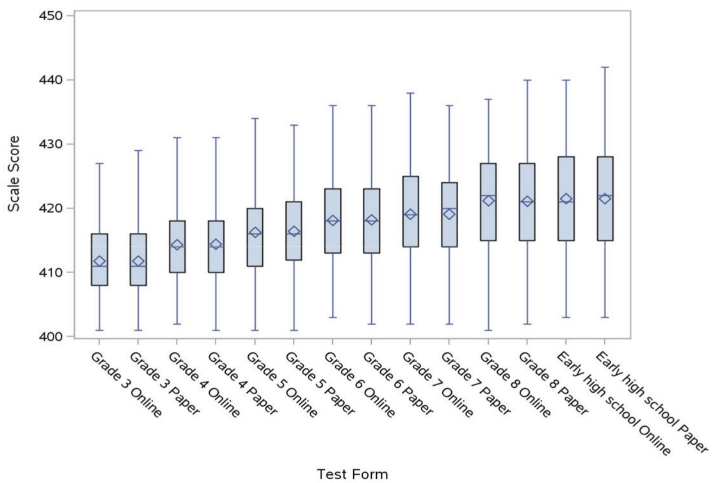
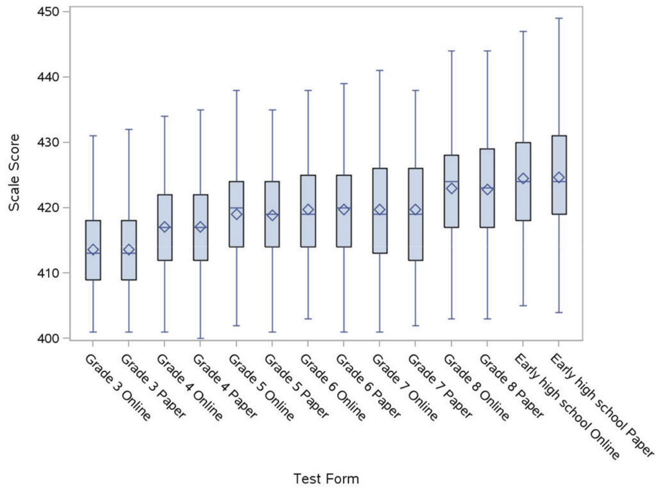



**Figure F.8. Box plots of scale scores by grade and mode for each subject area.**

Science




Writing

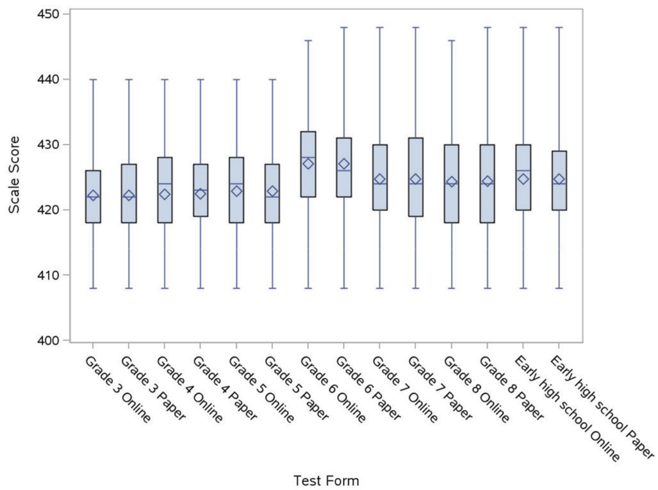



**Figure F.8. Box plots of scale scores by grade and mode for each subject area—continued.**

Based in part on these results, we argue that the statistical linking was successful in assuring that scale scores across paper and online modes were comparable. In other words, mode effects across online and paper forms were effectively eliminated; scale scores appeared to function similarly across modes.

# F.7 Summary

Based on the results comparing raw number-of-points scores on identical items across modes, it is preferable to assume that there are mode effects for ACT Aspire Summative Assessments. Not every grade and subject showed evidence of mode effects, but it occurred often enough that assuming that there were no mode effects is an unreasonable assumption. When mode effects were observed, they were generally relatively small and in some cases (e.g., writing) were inconsistent. If some degree of score differences due to mode were not a strong concern, it may be acceptable or even preferable to ignore mode effects on identical items across modes, but not under current interpretations of ACT Aspire scores.

As described above, some statistical link was required across modes due to item-type differences across modes. Statistical links appeared to successfully adjust for differences in items and across paper and online modes under the random groups design. Scale scores appeared comparable across modes.

# References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# Appendix G

# Concordance of ACT Aspire and PreACT/ACT Test Scores

The philosophical basis of the ACT Aspire, PreACT, and ACT tests are similar, and the design of all three tests is informed by the ACT National Curriculum Survey (ACT, 2020). All three tests report Composite (average of the English, math, reading, and science scores) and STEM scores (average of the math and science scores). ACT Aspire and the ACT test also report ELA scores (average of the English, reading, and writing scores). The tests also share reporting categories, which are used to group the items and tasks from the different domains represented on each test.

Concordance is used to align scores from two different tests that measure similar constructs; however, it does not result in score interchangeability and does not optimize prediction accuracy. Rather, concordance can be used to set comparable cut scores on two tests or to compare the performance of candidates who took different tests. A study was conducted in 2020 to generate concordance tables linking ACT Aspire scores to PreACT or ACT scores. We refer interested readers to an ACT report (Allen & Tao, 2020) for more details on the study, including:

- Procedures for generating samples of students used to estimate the concordances
- Test score summary statistics
- Demographic characteristics of the study samples
- Linking methodology (equipercentile linking)
- Comparison of results for PreACT and ACT test scores
- Cautions for using concordance tables

The concordances were estimated in both directions, allowing users to find ACT Aspire scores that are comparable to a given PreACT/ACT score or to find PreACT/ACT scores that are comparable to a given ACT Aspire score. Table G.1. provides the PreACT/ACT-to-ACT Aspire concordances and Table G.2. provides the ACT Aspire-to-PreACT/ACT concordances.

**Table G.1. PreACT/ACT to ACT Aspire Concordance**

| PreACT or ACT Score | Concordant ACT Aspire Score | | | | | | |
|---|---|---|---|---|---|---|---|
| | English | Math | Reading | Science | ELA | STEM | Composite |
| 1 | 400 | 400 | 400 | 400 | 403 | 400 | 400 |
| 2 | 402 | 401 | 401 | 401 | 405 | 401 | 401 |
| 3 | 403 | 402 | 402 | 402 | 406 | 402 | 402 |
| 4 | 405 | 403 | 403 | 403 | 407 | 404 | 404 |
| 5 | 406 | 404 | 404 | 404 | 409 | 405 | 405 |
| 6 | 408 | 405 | 405 | 405 | 410 | 406 | 406 |
| 7 | 409 | 406 | 406 | 406 | 412 | 407 | 407 |
| 8 | 412 | 407 | 407 | 408 | 413 | 408 | 408 |
| 9 | 414 | 408 | 408 | 409 | 414 | 409 | 409 |
| 10 | 416 | 409 | 409 | 410 | 416 | 411 | 411 |
| 11 | 419 | 410 | 411 | 412 | 417 | 412 | 412 |
| 12 | 421 | 411 | 412 | 414 | 420 | 413 | 414 |
| 13 | 423 | 412 | 415 | 416 | 422 | 414 | 416 |
| 14 | 426 | 416 | 417 | 418 | 424 | 417 | 419 |
| 15 | 428 | 419 | 419 | 421 | 426 | 420 | 422 |
| 16 | 430 | 424 | 421 | 423 | 428 | 422 | 424 |
| 17 | 432 | 427 | 423 | 425 | 429 | 425 | 426 |
| 18 | 433 | 429 | 424 | 427 | 431 | 427 | 428 |
| 19 | 435 | 431 | 426 | 429 | 432 | 430 | 430 |
| 20 | 436 | 433 | 427 | 431 | 433 | 432 | 432 |
| 21 | 438 | 434 | 428 | 433 | 434 | 433 | 433 |
| 22 | 440 | 435 | 430 | 435 | 435 | 435 | 435 |
| 23 | 442 | 436 | 431 | 437 | 436 | 436 | 436 |
| 24 | 443 | 438 | 432 | 438 | 437 | 438 | 437 |
| 25 | 445 | 439 | 432 | 440 | 438 | 439 | 438 |
| 26 | 445 | 441 | 433 | 441 | 438 | 440 | 439 |
| 27 | 447 | 442 | 433 | 441 | 439 | 442 | 440 |
| 28 | 448 | 443 | 434 | 442 | 440 | 442 | 441 |
| 29 | 448 | 444 | 434 | 443 | 441 | 443 | 442 |
| 30 | 449 | 445 | 435 | 444 | 441 | 444 | 443 |
| 31 | 449 | 445 | 435 | 444 | 442 | 445 | 443 |
| 32 | 450 | 447 | 436 | 444 | 443 | 446 | 444 |

**Table G.1. PreACT/ACT to ACT Aspire Concordance—continued**

| PreACT or ACT Score | Concordant ACT Aspire Score | | | | | | |
|---|---|---|---|---|---|---|---|
| | English | Math | Reading | Science | ELA | STEM | Composite |
| 33 | 451 | 447 | 437 | 445 | 445 | 447 | 445 |
| 34 | 451 | 448 | 437 | 446 | 446 | 449 | 447 |
| 35 | 453 | 453 | 439 | 447 | 447 | 452 | 449 |
| 36 | 456 | 460 | 442 | 449 | 449 | 455 | 452 |

**Table G.2. PreACT/ACT to ACT Aspire Concordance—continued**

| ACT Aspire Score | Concordant PreACT or ACT Score | | | | | | |
|---|---|---|---|---|---|---|---|
| | English | Math | Reading | Science | ELA | STEM | Composite |
| 400 | 1 | 1 | 1 | 1 | | 1 | 1 |
| 401 | 2 | 2 | 2 | 2 | | 2 | 2 |
| 402 | 2 | 3 | 3 | 3 | | 3 | 3 |
| 403 | 3 | 4 | 4 | 4 | 1 | 4 | 3 |
| 404 | 4 | 5 | 5 | 5 | 2 | 5 | 4 |
| 405 | 4 | 6 | 6 | 6 | 2 | 6 | 5 |
| 406 | 5 | 7 | 7 | 7 | 3 | 7 | 6 |
| 407 | 6 | 9 | 8 | 8 | 4 | 8 | 7 |
| 408 | 6 | 10 | 9 | 9 | 5 | 9 | 8 |
| 409 | 7 | 11 | 10 | 10 | 6 | 9 | 9 |
| 410 | 7 | 12 | 10 | 10 | 6 | 10 | 9 |
| 411 | 8 | 13 | 11 | 11 | 7 | 11 | 10 |
| 412 | 8 | 13 | 12 | 11 | 8 | 12 | 11 |
| 413 | 9 | 14 | 12 | 12 | 9 | 13 | 12 |
| 414 | 9 | 14 | 13 | 12 | 10 | 13 | 12 |
| 415 | 10 | 14 | 13 | 12 | 10 | 13 | 13 |
| 416 | 10 | 14 | 14 | 13 | 11 | 14 | 13 |
| 417 | 10 | 14 | 14 | 13 | 11 | 14 | 13 |
| 418 | 11 | 15 | 15 | 14 | 11 | 14 | 14 |
| 419 | 11 | 15 | 15 | 14 | 12 | 15 | 14 |
| 420 | 11 | 15 | 16 | 15 | 12 | 15 | 14 |
| 421 | 12 | 15 | 16 | 15 | 13 | 16 | 15 |
| 422 | 12 | 16 | 16 | 16 | 13 | 16 | 15 |
| 423 | 13 | 16 | 17 | 16 | 13 | 16 | 16 |
| 424 | 13 | 16 | 18 | 17 | 14 | 17 | 16 |
| 425 | 14 | 16 | 19 | 17 | 14 | 17 | 16 |
| 426 | 14 | 17 | 19 | 18 | 15 | 17 | 17 |
| 427 | 15 | 17 | 20 | 18 | 16 | 18 | 17 |
| 428 | 15 | 17 | 21 | 19 | 16 | 18 | 18 |
| 429 | 15 | 18 | 22 | 19 | 17 | 19 | 19 |
| 430 | 16 | 18 | 22 | 20 | 18 | 19 | 19 |

**Table G.2. PreACT/ACT to ACT Aspire Concordance—continued**

| ACT Aspire Score | Concordant PreACT or ACT Score | | | | | | |
|---|---|---|---|---|---|---|---|
| | English | Math | Reading | Science | ELA | STEM | Composite |
| 431 | 16 | 19 | 23 | 20 | 18 | 20 | 20 |
| 432 | 17 | 20 | 24 | 20 | 19 | 20 | 20 |
| 433 | 18 | 20 | 26 | 21 | 20 | 21 | 21 |
| 434 | 18 | 21 | 28 | 22 | 21 | 21 | 22 |
| 435 | 19 | 22 | 30 | 22 | 22 | 22 | 22 |
| 436 | 20 | 23 | 32 | 23 | 23 | 23 | 23 |
| 437 | 20 | 23 | 34 | 23 | 24 | 23 | 24 |
| 438 | 21 | 24 | 35 | 24 | 25 | 24 | 25 |
| 439 | 21 | 25 | 35 | 24 | 27 | 25 | 26 |
| 440 | 22 | 25 | 36 | 25 | 28 | 26 | 27 |
| 441 | 22 | 26 | 36 | 26 | 29 | 26 | 28 |
| 442 | 23 | 27 | 36 | 28 | 31 | 27 | 29 |
| 443 | 24 | 28 | | 29 | 31 | 29 | 30 |
| 444 | 25 | 29 | | 31 | 32 | 30 | 32 |
| 445 | 25 | 30 | | 33 | 33 | 31 | 33 |
| 446 | 26 | 32 | | 34 | 34 | 32 | 33 |
| 447 | 27 | 32 | | 35 | 35 | 33 | 34 |
| 448 | 29 | 34 | | 35 | 35 | 34 | 34 |
| 449 | 30 | 34 | | 36 | 36 | 34 | 35 |
| 450 | 32 | 34 | | | | 35 | 35 |
| 451 | 33 | 35 | | | | 35 | 36 |
| 452 | 35 | 35 | | | | 35 | 36 |
| 453 | 35 | 35 | | | | 36 | |
| 454 | 35 | 35 | | | | 36 | |
| 455 | 35 | 35 | | | | 36 | |
| 456 | 36 | 36 | | | | | |
| 457 | | 36 | | | | | |
| 458 | | 36 | | | | | |
| 459 | | 36 | | | | | |
| 460 | | 36 | | | | | |

The concordances can be used to:

- Set comparable cut scores. For example, suppose that a district has an existing cut score for entrance into a concurrent enrollment math course, and the cut score is based on the ACT or PreACT math test. Table G.1. can be used to find the ACT Aspire math score that is comparable to the existing cut score. Then, the district may elect to allow students to use the ACT Aspire math test to qualify for the concurrent enrollment course.
- Understand the readiness of students who took different tests. For example, suppose that a district administers the PreACT test to all 10th-grade students. New students entering the district in 11th grade did not take the PreACT test but did take ACT Aspire in 10th grade. Table G.2. can be used to find the PreACT test scores that are comparable to the ACT Aspire scores. The district can use the concordant PreACT test scores to understand the readiness levels of the new students.
- Align scores for research purposes. Research studies may utilize ACT Aspire, PreACT, and ACT scores. The concordances can be used to align the scores to a common scale and thus enabling data analyses that incorporate students regardless of which tests they took.

## References

Allen, J., & Tao, W. (2020). Concordance of ACT Aspire and PreACT/ACT Test Scores. Iowa City, IA: ACT.

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## About ACT

ACT is a mission-driven, nonprofit organization dedicated to helping people achieve education and workplace success. Grounded in 60 years of research, ACT is a trusted leader in college and career readiness solutions. Each year, ACT serves millions of students, job seekers, schools, government agencies and employers in the US and around the world with learning resources, assessments, research and credentials designed to help them succeed from elementary school through career. To learn more, visit us at act.org.