

Technical Manual Supplement

The ACT[®]



Contents

- Preface iii
- Introduction iv
- 1. ACT Test Reporting Categories and Blueprints 1.1
 - 1.1. English Test 1.4
 - 1.1.1.English Reporting Categories 1.4
 - 1.1.2.English Test Blueprints 1.5
 - 1.2. Mathematics Test 1.5
 - 1.2.1.Mathematics Reporting Categories 1.5
 - 1.2.2.Mathematics Test Blueprints 1.9
 - 1.3. Reading Test 1.9
 - 1.3.1.Reading Reporting Categories 1.9
 - 1.3.2.Reading Test Blueprints 1.10
 - 1.4. Science Test 1.10
 - 1.4.1.Science Reporting Categories 1.10
 - 1.4.2.Science Test Blueprints 1.11
 - 1.5. Writing Test 1.11
 - 1.5.1.Writing Scores and Domains 1.11
 - 1.5.2.Writing Scoring Rubric 1.13
 - 1.5.3.Writing Field Tests, Prompt Selection, and Comparability of the Overall Writing Scores 1.15
 - 1.5.4.Scaling and Equating of the Writing Scores for ELA Calculation 1.15
 - 1.5.5.Writing Reliability and Standard Error of Measurement 1.16
- 2. Additional Scores and Indicators 2.1
 - 2.1. STEM and ELA Scores 2.1
 - 2.2. Understanding Complex Texts 2.7
 - 2.3. Progress Toward the ACT National Career Readiness Certificate 2.9
 - 2.4. Interest-Major Fit 2.10
- 3. Student, High School, and College Reports 3.1
 - 3.1. Student Report 3.2
 - 3.2. High School Report 3.5
 - 3.3. College Report 3.7
- 4. Online Testing and Mode Comparability 4.1
 - 4.1. ACT Online Test Administration 4.1
 - 4.2. Online Platform and Capabilities 4.1
 - 4.3. Comparability of Scores from Online and Paper Testing 4.2
 - 4.3.1.Fall 2013 Timing Study 4.2
 - 4.3.2.Spring 2014 and Spring 2015 Mode Comparability Studies 4.2
- 5. References 5.1

Tables

Table 1.1. Reliability and Standard Error of Measurement Summary Statistics of the ACT Tests Reporting Category Scores	1.3
Table 1.2. Specification Ranges by Item Type and Reporting Category for English	1.5
Table 1.3. Specification Ranges by Item Type and Reporting Category for Mathematics	1.9
Table 1.4. Specification Ranges by Item Type and Reporting Category for Reading	1.10
Table 1.5. Specification Ranges by Item Type and Reporting Category for Science	1.11
Table 1.6. Writing Test Analytic Scoring Rubric	1.13
Table 2.1. Scale Score Summary Statistics of the ACT Test Scores for Five of the 2015–2016 National ACT Administrations	2.2
Table 2.2. Scale Score Reliability and Standard Error of Measurement Summary Statistics for Five of the 2015–2016 National ACT Administrations	2.2
Table 2.3. Composite Score Ranges for the ACT NCRC Levels	2.10

Figures

Figure 1.1. Detailed Results example from the 2016–2017 ACT score report	1.2
Figure 1.2. Average and fitted CSEMs for writing scores	1.16
Figure 2.1. Conditional standard errors of measurement of the STEM scores for five of the forms used in 2015–2016 national ACT administrations	2.3
Figure 2.2. Conditional standard errors of measurement of the ELA scores for five of the forms used in 2015–2016 national ACT administrations	2.4
Figure 2.3. Probability of persisting in a STEM major at years 2, 3, and 4 by ACT STEM score at a typical four-year institution	2.7
Figure 3.1. 2016-17 ACT sample student report	3.2
Figure 3.2. 2016-17 ACT sample high school report	3.4
Figure 3.3. 2016-17 ACT sample college report	3.6

Preface

This supplement contains technical information about updates to the ACT®. It is intended to accompany the *ACT Technical Manual* as the two together represent comprehensive documentation of the technical characteristics of the ACT in light of its intended purposes. ACT regularly conducts research as part of the ongoing evaluation of its programs. The research is intended to ensure that the programs remain technically 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.

Please direct comments or inquiries to the address below:

Research Services

ACT, Inc.

500 ACT Drive

Iowa City, Iowa 52243-0168

Introduction

Starting in the fall of 2015, ACT began implementing a series of updates to the ACT tests, including changes to the ACT writing test, reporting of new scores, inclusion of an online testing option for state and district testing, and enhancements to the student, high school, and college score reports. These updates are presented in this supplement to the *ACT Technical Manual*.

Prior to September 2015, scale scores from the four multiple-choice tests, composite scores, subscores, writing scores, and combined English/writing scores were reported to students. In September 2015, ACT began reporting Science, Technology, Engineering, and Mathematics (STEM) and English Language Arts (ELA) scores in addition to the four multiple-choice test scale scores and Composite scores. Understanding Complex Texts and Progress Toward the ACT National Career Readiness Certificate indicators were also first reported to students in 2015. Changes were made to the ACT writing test beginning in the 2015–2016 academic year, including the adoption of analytic scoring for essays and reporting of four new writing domain scores. Beginning in September 2016, ACT is reporting the overall ACT writing test score as the average of the four domain scores. In addition, reporting category scores and ACT Readiness Ranges replace subscores, and score reports are redesigned to allow students and educators to better navigate results and gain more meaningful insights.

This document provides information about the reporting categories, changes in the writing test, and other newly reported scores, followed by a detailed introduction of the redesigned score reports. Studies supporting the comparability of scores from online and paper testing are also described.

CHAPTER 1

ACT Test Reporting Categories and Blueprints

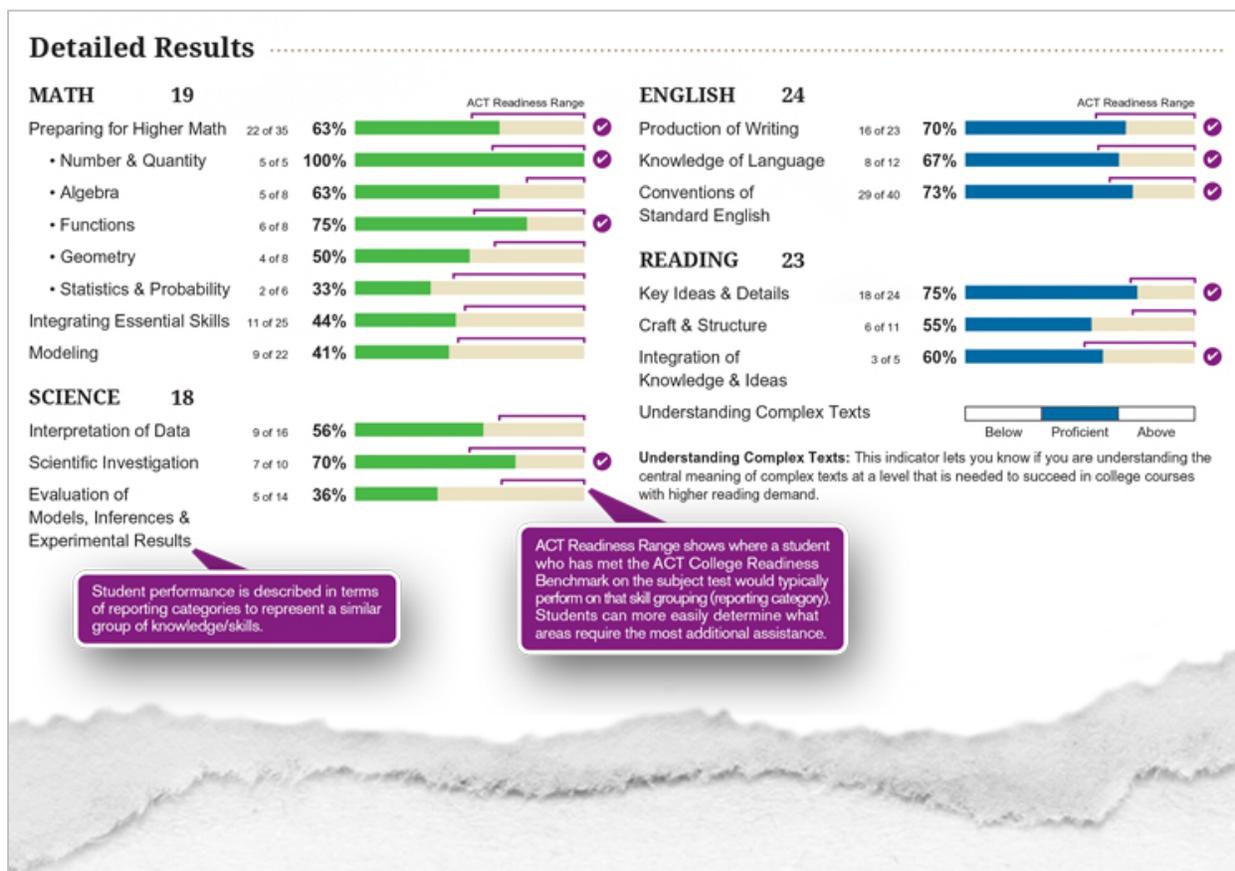
Since fall 2015, score reports have contained readiness scores and indicators designed to show performance and preparedness in areas important to success after high school. For students to gain insights into possible directions for college and career, they need to understand their areas of strength and also those areas where they need to improve. Starting in the 2016–2017 academic year, the addition of ACT reporting categories and ACT Readiness Ranges are important enhancements to the ACT score reports.

The new score reports incorporate a comprehensive set of reporting categories for each subject area of the test (see Figure 1.1 below). Reporting categories group and report on similar skills to provide students with more detailed information within each subject. The new reporting category scores replace the subscores (e.g., Intermediate Algebra/Coordinate Geometry) that were previously reported. ACT reporting categories are aligned with ACT College and Career Readiness Standards and other standards that target college and career readiness. There are three reporting categories each for English, reading, and science and eight for mathematics. The number of items for a particular reporting category can vary across different test forms. Because these scores are raw scores, they are not directly comparable across different test forms. For each reporting category, the score report shows the total number of points possible, the number of correct responses, the percent of correct responses, and the ACT Readiness Range.

Also, the blueprint tables for each subject test include information about the Depth of Knowledge (DOK) levels assessed across items. DOK levels reflect the complexity of the cognitive process required to solve the item, not the psychometric “difficulty” of the item. Unlike other DOK interpretations, ACT only assigns a DOK level 4 value to describe multiday, potentially collaborative classroom activities and assessments designed for learning purposes. By this definition, DOK assignments on any summative assessment (including the ACT) are limited to values from 1 to 3.

The ACT Readiness Ranges enable students to see at a glance how their performance on each reporting category compares to students who have met the ACT College Readiness Benchmark for that specific subject. For each reporting category, the ACT Readiness Range was calculated by regressing the percentage of points achieved on students' scale scores for the corresponding subject. The minimum value of the range is the point that corresponds to the predicted percentage of points that would be achieved by a student whose score is at the ACT College Readiness Benchmark on the overall subject test. The maximum value of the range corresponds to answering all questions in that reporting category correctly. The ACT Readiness Ranges appear on the Student Score Report and the High School Score Report. The combination of reporting category scores and the ACT Readiness Ranges provides educators and students with information to more clearly show which areas require the most assistance for additional learning and intervention.

Figure 1.1. Detailed Results example from the 2016–2017 ACT score report.



Reliability and Standard Error of Measurement (SEM)

The reliability (coefficient alpha) and SEM for the reporting category number correct scores are shown in Table 1.1. Data were compiled from 12 forms administered in 2015. For some of the reporting categories, particularly those with very few items, the reliability is low. However, reporting category scores are not intended for high stakes decisions. They are intended to guide instruction and help identify students' strengths and weaknesses. For more information on the interpretation of the reporting categories, see Powers, Li, Suh, and Harris (2016).

Table 1.1. Reliability and SEM* Summary Statistics of the ACT Tests Reporting Category Scores

Test/Reporting Categories	Median # of Items	Reliability			SEM		
		Median	Minimum	Maximum	Median	Minimum	Maximum
English							
Production of Writing	23	0.81	0.77	0.82	2.07	1.99	2.12
Knowledge of Language	12	0.67	0.61	0.72	1.46	1.36	1.52
Conventions of Standard English	40	0.86	0.84	0.88	2.67	2.58	2.74
Mathematics							
Preparing for Higher Math	35	0.84	0.80	0.86	2.51	2.47	2.56
Number & Quantity	5	0.35	0.26	0.54	0.95	0.89	1.00
Algebra	8	0.54	0.49	0.65	1.19	1.13	1.23
Functions	8	0.59	0.45	0.65	1.20	1.15	1.24
Geometry	8	0.55	0.48	0.60	1.22	1.13	1.26
Statistics & Probability	6	0.42	0.34	0.51	1.06	1.01	1.09
Integrating Essential Skills	25	0.81	0.77	0.84	2.11	2.07	2.17
Modeling	24	0.79	0.71	0.84	2.07	1.73	2.32
Reading							
Key Ideas & Details	23	0.78	0.73	0.80	2.10	2.02	2.21
Craft & Structure	11	0.60	0.54	0.65	1.45	1.32	1.54
Integration of Knowledge & Ideas	6	0.43	0.34	0.55	1.09	0.82	1.14
Science							
Interpretation of Data	18	0.72	0.60	0.76	1.77	1.51	1.88
Scientific Investigation	10	0.59	0.47	0.69	1.39	1.17	1.71
Evaluation of Models, Inferences & Experimental Results	12	0.61	0.45	0.74	1.55	1.28	1.69

*Standard error of measurement

1.1. English Test

1.1.1. English Reporting Categories

Four scores are reported for the ACT English test: a total test score based on all 75 questions and three reporting category scores. The three reporting categories associated with the English test are Production of Writing, Knowledge of Language, and Conventions of Standard English. These reporting categories are subdivided into six elements, each of which targets an aspect of effective writing. A brief description of the reporting categories is provided below, and the approximate percentage of the test items in each reporting category are given in Table 1.2. In addition, the overall English test score, along with the reading and writing test scores, is used to determine the ELA score.

Production of Writing

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

- **Topic Development:** Students demonstrate an understanding of, and control over, the rhetorical aspects of texts by identifying the purposes of parts of texts, determining whether a text or part of a text has met its intended goal, 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 through 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.

- **Sentence Structure and Formation:** Students apply an understanding of relationships between and among clauses, placement of modifiers, and shifts in sentence construction.
- **Usage:** Students edit text to conform to Standard English usage.
- **Punctuation:** Students edit text to conform to Standard English punctuation.

1.1.2. English Test Blueprints

Table 1.2. Specification Ranges by Item Type and Reporting Category for English

	Number of Items	Percentage of Test
Reporting Categories		
Production of Writing	22–24	29–32%
Knowledge of Language	11–13	15–17%
Conventions of Standard English	39–41	52–55%
Depth of Knowledge (DOK)		
DOK Level 1	22–30	30–40%
DOK Level 2	15–18	20–24%
DOK Level 3	25–31	33–41%
Total Number of Items	75	100%

1.2. Mathematics Test

1.2.1. Mathematics Reporting Categories

Nine scores are reported for the ACT mathematics test: a total test score based on all 60 questions and eight reporting category scores. The eight reporting categories addressed in the mathematics test are Preparing for Higher Math, which includes separate scores for Number & Quantity, Algebra, Functions, Geometry, and Statistics & Probability; Integrating Essential Skills; and Modeling. A description and the approximate percentage of the test devoted to each reporting category are given in Table 1.3. The overall score on the mathematics test is also used, with the science score, to determine the STEM score.

Preparing for Higher Math

This reporting category captures the more recent mathematics that students are learning, starting when students begin using algebra as a general way of expressing and solving equations. This category is divided into the following five subcategories.

- Number & Quantity**
 Coming into high school, students have some knowledge of the real number system. Because they have an understanding of and fluency with rational numbers and the four basic operations, they can work with irrational numbers by manipulating rational numbers that are close. Students are ready to move from integer exponents to rational exponents and are also ready to probe deeper into properties of the real number system. Students extend their knowledge to include complex numbers, which offer the solutions to some simple equations that have no real-number solutions, and students learn to compute in this system. Students go further, exploring properties of complex numbers—again, learning more about real numbers. Students explore vectors and matrices and 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.

- **Algebra**

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. They continue to make sense of expressions in terms of their parts in order to use their fluency strategically and to solve problems. Through repeated reasoning, students develop a general understanding of solving equations as a process that provides justification that all the solutions will be found. Students extend their proficiency to equations such as quadratic, polynomial, rational, radical, and systems, integrating an understanding of solutions in terms of graphs. Families of equations have properties that make them useful for modeling. Polynomials form a system analogous to adding, subtracting, and multiplying integers; solutions of polynomial equations are related to factors of a polynomial. Students recognize these relationships in applications and create expressions, equations, and inequalities to represent problems and constraints. Students see rational expressions as a system analogous to rational numbers, apply the binomial theorem, and solve simple matrix equations that represent systems of linear equations.

- **Functions**

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.” Understanding 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 become adept at interpreting the characteristics of functions in the context of a problem and become attuned to differences between a model and reality. Some functions accept all numbers as inputs, but many accept only some numbers. Function notation gives another way to express functions that highlights properties and behaviors. Students work with functions that have no equation, functions that follow the pattern of an equation, and functions based on sequences, which can even be recursive. Students investigate particular families of functions—like linear, quadratic, and exponential—in terms of the general function framework: looking at rates of change, algebraic properties, and connections to graphs and tables, and applying these functions in modeling situations. Students also examine a range of functions like those defined in terms of square roots, cube roots, polynomials, exponentials, logarithms, and trigonometric relationships, and also piecewise-defined functions.

Students see solving an equation in terms of an inverse function. Students have seen shifts in graphs due to parameter changes, but now they develop a unified understanding of translations and scaling through forms such as $f(x - c)$, $f(x) + c$, $a f(x)$ and $f(-ax)$. Students connect the trigonometry of right triangles to the unit circle to make

trigonometric functions, and they explore algebraic relationships among these functions. They use these functions to model periodic behavior.

Students graph rational functions and learn about asymptotes. They compose functions in other ways besides translation and scaling, going deeper into how inverse functions apply to solving equations with more than one solution, in particular for trigonometric functions. They explore algebraic properties of trigonometric functions such as angle addition properties.

- **Geometry**

In high school, students add depth to what they know about transformations, reflections, rotations, and dilations and add precision to their understanding of congruence, similarity, and symmetry. 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 understand trigonometric ratios as functions of the angle through the lens of similar triangles, and they 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, to split a line segment into pieces with a given ratio of lengths, to find areas, and to develop equations for circles and for parabolas that have a directrix parallel to an axis.

Students go further into trigonometry, deriving a formula for the area of a general triangle in terms of side lengths and the sine of an angle, moving on to the law of sines and law of cosines, which give straightforward answers to questions about nonright triangles. Students derive equations for ellipses and hyperbolas. Students use Cavalieri's principle to justify formulas, such as the formula for volume of a sphere.

- **Statistics & Probability**

In high school, 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. Students describe distance from the mean in standard-deviation units, and for distributions that look approximately normal, they approximate the probability of events using probabilities from the normal distribution.

Before high school, students have used two-way tables and scatter plots to look at relationships between different quantities and have 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; they use models for prediction, interpreting characteristics of the model in the context of the data, and interpreting the correlation coefficient for linear models. 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.

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 have 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, and later using the ideas of conditional probability. Students understand the multiplicative rule for conditional probability and study permutations and combinations as a tool for counting. Students model a sample space with a “random variable” by giving a numerical value to each event. Students apply expected value and probability to help inform decisions.

Integrating Essential Skills

Students learn some of the most useful mathematics before eighth grade: rates and percentages; proportional relationships; area, surface area, and volume; average and median; expressing numbers in different ways; using expressions to represent quantities and equations to capture relationships; and other topics. Each year, students should grow in what they can accomplish using learning from prior years. Students should be able to solve problems of increasing complexity, combine skills in longer chains of steps, apply skills in more varied contexts, understand more connections, and increase fluency. In order to assess whether students have had appropriate growth, questions in this reporting category are at a cognitive level of at least depth of knowledge level 2 for high school students, with a significant portion at depth of knowledge level 3.

Modeling

Modeling uses mathematics to represent with a model an analysis of an actual, empirical situation. Models often help us predict or understand the actual. However, sometimes knowledge of the actual helps us understand the model, such as when addition is introduced to students as a model of combining two groups. The Modeling reporting category represents all questions that involve producing, interpreting, understanding, evaluating, and improving models. Each modeling question is also counted in the other appropriate reporting categories above. Thus, the Modeling reporting category is an overall measure of how well a student uses modeling skills across mathematical topics.

1.2.2. Mathematics Test Blueprints

Table 1.3. Specification Ranges by Item Type and Reporting Category for Mathematics

		Number of Items	Percentage of Test
Reporting Categories			
Preparing for Higher Math		34–36	57–60%
Number & Quantity		4–6	7–10%
Algebra		7–9	12–15%
Functions		7–9	12–15%
Geometry		7–9	12–15%
Statistics & Probability		5–7	8–12%
Integrating Essential Skills		24–26	40–43%
Modeling		≥ 16	≥ 27%
Depth of Knowledge (DOK)			
DOK Level 1	Preparing for Higher Math	7–9	12–15%
	Integrating Essential Skills	—	0%
DOK Level 2	Preparing for Higher Math	17–19	28–32%
	Integrating Essential Skills	15–17	25–28%
DOK Level 3	Preparing for Higher Math	8–10	13–17%
	Integrating Essential Skills	8–10	13–17%
Total Number of Items		60	100%

1.3. Reading Test

1.3.1. Reading Reporting Categories

Five scores are reported for the ACT reading test: a total test score based on all 40 questions, three reporting category scores based on specific knowledge and skills, and an Understanding Complex Texts indicator. The three reporting categories addressed in the reading test are Key Ideas & Details, Craft & Structure, and Integration of Knowledge & Ideas. In addition, the overall reading test score, along with the English and writing test scores, is used to determine the ELA score. A description and the approximate percentage of the test devoted to each reporting category are given in Table 1.4.

Key Ideas & Details

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

Craft & Structure

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

Integration of Knowledge & Ideas

Students understand authors' claims, differentiate between facts and opinions, and use evidence to make connections between different texts that are related by topic. Some questions will require students to analyze how authors construct arguments, evaluating reasoning and evidence from various sources.

1.3.2. Reading Test Blueprints

Table 1.4. Specification Ranges by Item Type and Reporting Category for Reading

	Number of Items	Percentage of Test
Reporting Categories		
Key Ideas & Details	22–24	55–60%
Craft & Structure	10–12	25–30%
Integration of Knowledge & Ideas	6–7	15–18%
Depth of Knowledge (DOK)		
DOK Level 1	5–10	13–25%
DOK Level 2	15–25	38–63%
DOK Level 3	10–20	25–50%
Total Number of Items	40	100%

1.4. Science Test

1.4.1. Science Reporting Categories

Four scores are reported for the ACT science test: a total test score based on all 40 questions and three reporting category scores based on scientific knowledge, skills, and practices. The three reporting categories addressed in the science test are Interpretation of Data; Scientific Investigation; and Evaluation of Models, Inferences & Experimental Results. A description and the approximate percentage of the test devoted to each reporting category are given in Table 1.5. The overall score on the science test is also used, with the math score, to determine the STEM score.

Interpretation of Data

Students manipulate and analyze scientific data presented in tables, graphs, and diagrams (e.g., recognize trends in data, translate tabular data into graphs, interpolate and extrapolate, and reason mathematically).

Scientific Investigation

Students understand experimental tools, procedures, and design (e.g., identify variables and controls) and compare, extend, and modify experiments (e.g., predict the results of additional trials).

Evaluation of Models, Inferences & Experimental Results

Students judge the validity of scientific information and formulate conclusions and predictions based on that information (e.g., determine which explanation for a scientific phenomenon is supported by new findings).

1.4.2. Science Test Blueprints

Table 1.5. Specification Ranges by Item Type and Reporting Category for Science

	Number of Items	Percentage of Test
Reporting Categories		
Interpretation of Data	18–22	45–55%
Scientific Investigation	8–12	20–30%
Evaluation of Models, Inferences & Experimental Results	10–14	25–35%
Depth of Knowledge (DOK)		
DOK Level 1	2–8	5–20%
DOK Level 2	20–30	50–75%
DOK Level 3	8–16	20–40%
Total Number of Items	40	100%

1.5. Writing Test

The ACT writing test is a 40-minute essay test that measures students' writing skills—specifically those skills emphasized in high school English classes and in entry-level college composition courses. The information from the writing test tells postsecondary institutions about students' ability to think critically about an issue, consider different perspectives on it, and compose an effective argumentative essay in a timed condition. An image of the essay will be available to the student's high school and the colleges selected for score reporting.

The writing test underwent a number of enhancements that became operational in September 2015. The enhanced test consists of one writing prompt that describes a complex issue and presents three different perspectives on that issue.

Students are asked to read the prompt and write an essay in which they develop their own perspective on the issue. The essay must analyze the relationship between their own perspective and one or more other perspectives. Students may adopt one of the perspectives given in the prompt as their own, or they may introduce one that is completely different from those given. Their score will not be affected by the point of view they take on the issue.

1.5.1. Writing Scores and Domains

Students who take the optional writing test receive a total of five scores: a single subject-level writing score reported on a range of 2–12¹ and four domain scores, also 2–12, that are based on an analytic scoring rubric. The subject-level score is the rounded average of the four domain scores.

Taking the writing test does not affect the student's subject area scores or Composite score. However, a writing test score, along with the overall English and reading test scores are needed to report an ELA score.

The four writing test domain scores addressed in the writing test are Ideas & Analysis, Development & Support, Organization, and Language Use & Conventions. Two trained readers score each essay on a scale from 1–6 in each of the four domains. Each domain score represents the sum of the two readers' scores using the analytic rubric in Table 1.6. If the readers' ratings disagree by more than one point, a third reader evaluates the essay and resolves the discrepancy.

Ideas & Analysis

Scores in this domain reflect the ability to generate productive ideas and engage critically with multiple perspectives on the given issue. Competent writers understand the issue they are invited to address, the purpose for writing, and the audience. They generate ideas that are relevant to the situation.

Development & Support

Scores in this domain reflect the ability to discuss ideas, offer rationale, and strengthen an argument. Competent writers explain and explore their ideas, discuss implications, and illustrate through examples. They help the reader understand their thinking about the issue.

Organization

Scores in this domain reflect the ability to organize ideas with clarity and purpose. Organizational choices are integral to effective writing. Competent writers arrange their essay in a way that clearly shows the relationship between ideas, and they guide the reader through their discussion.

Language Use & Conventions

Scores in this domain reflect the ability to use written language to clearly convey ideas. Competent writers make use of the conventions of grammar, syntax, word usage, and mechanics. They are also aware of their audience and adjust the style and tone of their writing to communicate effectively.

¹ Students who took the writing test from September 2015 to June 2016 received a subject-level writing score reported on a 1–36 scale and not the 2–12 subject-level score that is currently reported. It should also be noted that the current 2–12 subject-level writing score is not the same as the 2–12 score from the former writing test (June 2015 and before). Although both tests measure a student's ability to write an effective argumentative essay, the current test has a new design. The current test is also scored with an analytic rubric, whereas the former writing test was scored with a holistic six-point rubric. The score on the former test was the sum of the two raters' (1–6) scores rather than the rounded average of four (2–12) domain scores.

1.5.2 Writing Scoring Rubric

Table 1.6. Writing Test Analytic Scoring Rubric

	<i>Ideas and Analysis</i>	<i>Development and Support</i>	<i>Organization</i>	<i>Language Use</i>
Score 6: Responses at this scorepoint demonstrate effective skill in writing an argumentative essay.	The writer generates an argument that critically engages with multiple perspectives on the given issue. The argument’s thesis reflects nuance and precision in thought and purpose. The argument establishes and employs an insightful context for analysis of the issue and its perspectives. The analysis examines implications, complexities and tensions, and/or underlying values and assumptions.	Development of ideas and support for claims deepen insight and broaden context. An integrated line of skillful reasoning and illustration effectively conveys the significance of the argument. Qualifications and complications enrich and bolster ideas and analysis.	The response exhibits a skillful organizational strategy. The response is unified by a controlling idea or purpose, and a logical progression of ideas increases the effectiveness of the writer’s argument. Transitions between and within paragraphs strengthen the relationships among ideas.	The use of language enhances the argument. Word choice is skillful and precise. Sentence structures are consistently varied and clear. Stylistic and register choices, including voice and tone, are strategic and effective. While a few minor errors in grammar, usage, and mechanics may be present, they do not impede understanding.
Score 5: Responses at this scorepoint demonstrate well-developed skill in writing an argumentative essay.	The writer generates an argument that productively engages with multiple perspectives on the given issue. The argument’s thesis reflects precision in thought and purpose. The argument establishes and employs a thoughtful context for analysis of the issue and its perspectives. The analysis addresses implications, complexities and tensions, and/or underlying values and assumptions.	Development of ideas and support for claims deepen understanding. A mostly integrated line of purposeful reasoning and illustration capably conveys the significance of the argument. Qualifications and complications enrich ideas and analysis.	The response exhibits a productive organizational strategy. The response is mostly unified by a controlling idea or purpose, and a logical sequencing of ideas contributes to the effectiveness of the argument. Transitions between and within paragraphs consistently clarify the relationships among ideas.	The use of language works in service of the argument. Word choice is precise. Sentence structures are clear and varied often. Stylistic and register choices, including voice and tone, are purposeful and productive. While minor errors in grammar, usage, and mechanics may be present, they do not impede understanding.
Score 4: Responses at this scorepoint demonstrate adequate skill in writing an argumentative essay.	The writer generates an argument that engages with multiple perspectives on the given issue. The argument’s thesis reflects clarity in thought and purpose. The argument establishes and employs a relevant context for analysis of the issue and its perspectives. The analysis recognizes implications, complexities and tensions, and/or underlying values and assumptions.	Development of ideas and support for claims clarify meaning and purpose. Lines of clear reasoning and illustration adequately convey the significance of the argument. Qualifications and complications extend ideas and analysis.	The response exhibits a clear organizational strategy. The overall shape of the response reflects an emergent controlling idea or purpose. Ideas are logically grouped and sequenced. Transitions between and within paragraphs clarify the relationships among ideas.	The use of language conveys the argument with clarity. Word choice is adequate and sometimes precise. Sentence structures are clear and demonstrate some variety. Stylistic and register choices, including voice and tone, are appropriate for the rhetorical purpose. While errors in grammar, usage, and mechanics are present, they rarely impede understanding.

	<i>Ideas and Analysis</i>	<i>Development and Support</i>	<i>Organization</i>	<i>Language Use</i>
<p>Score 3: Responses at this scorepoint demonstrate some developing skill in writing an argumentative essay.</p>	<p>The writer generates an argument that responds to multiple perspectives on the given issue. The argument's thesis reflects some clarity in thought and purpose. The argument establishes a limited or tangential context for analysis of the issue and its perspectives. Analysis is simplistic or somewhat unclear.</p>	<p>Development of ideas and support for claims are mostly relevant but are overly general or simplistic. Reasoning and illustration largely clarify the argument but may be somewhat repetitious or imprecise.</p>	<p>The response exhibits a basic organizational structure. The response largely coheres, with most ideas logically grouped. Transitions between and within paragraphs sometimes clarify the relationships among ideas.</p>	<p>The use of language is basic and only somewhat clear. Word choice is general and occasionally imprecise. Sentence structures are usually clear but show little variety. Stylistic and register choices, including voice and tone, are not always appropriate for the rhetorical purpose. Distracting errors in grammar, usage, and mechanics may be present, but they generally do not impede understanding.</p>
<p>Score 2: Responses at this scorepoint demonstrate weak or inconsistent skill in writing an argumentative essay.</p>	<p>The writer generates an argument that weakly responds to multiple perspectives on the given issue. The argument's thesis, if evident, reflects little clarity in thought and purpose. Attempts at analysis are incomplete, largely irrelevant, or consist primarily of restatement of the issue and its perspectives.</p>	<p>Development of ideas and support for claims are weak, confused, or disjointed. Reasoning and illustration are inadequate, illogical, or circular, and fail to fully clarify the argument.</p>	<p>The response exhibits a rudimentary organizational structure. Grouping of ideas is inconsistent and often unclear. Transitions between and within paragraphs are misleading or poorly formed.</p>	<p>The use of language is inconsistent and often unclear. Word choice is rudimentary and frequently imprecise. Sentence structures are sometimes unclear. Stylistic and register choices, including voice and tone, are inconsistent and are not always appropriate for the rhetorical purpose. Distracting errors in grammar, usage, and mechanics are present, and they sometimes impede understanding.</p>
<p>Score 1: Responses at this scorepoint demonstrate little or no skill in writing an argumentative essay.</p>	<p>The writer fails to generate an argument that responds intelligibly to the task. The writer's intentions are difficult to discern. Attempts at analysis are unclear or irrelevant.</p>	<p>Ideas lack development, and claims lack support. Reasoning and illustration are unclear, incoherent, or largely absent.</p>	<p>The response does not exhibit an organizational structure. There is little grouping of ideas. When present, transitional devices fail to connect ideas.</p>	<p>The use of language fails to demonstrate skill in responding to the task. Word choice is imprecise and often difficult to comprehend. Sentence structures are often unclear. Stylistic and register choices are difficult to identify. Errors in grammar, usage, and mechanics are pervasive and often impede understanding.</p>

1.5.3 Writing Field Tests, Prompt Selection, and Comparability of the Overall Writing Scores

ACT conducts a special field test study each year to evaluate new potential ACT writing prompts to select those suitable for operational use. Prompts are evaluated from both content and statistical perspectives to ensure scores are comparable across different test forms and different administrations. In each field test study, anchor prompts and new prompts are administered to randomly equivalent groups of approximately 1,000 students per prompt. Each student takes two prompts, and the order in which the prompts are taken is counterbalanced. Prompts are spiraled within classrooms so that, across all participating students, randomly equivalent groups of students take each prompt with about half of the students taking the prompt first and the rest taking it second.

To ensure the comparability of the 2–12 overall writing scores, prompts are selected for operational use if they perform similarly to the anchor prompts, meaning the distributions of 2–12 scores is similar across the prompts, using equating methodology. A similar procedure had been used to ensure the comparability of the ACT writing scores prior to fall 2015.

1.5.4. Scaling and Equating of the Writing Scores for ELA Calculation

The writing test also has a secondary score scale ranging from 1 to 36 that is combined with the ACT English and reading scores to provide an ELA score. The 1–36 writing scale was constructed based on data from the first special field test study of the enhanced writing prompts in fall 2014. After evaluating all prompts administered in the special study, one prompt was selected to be the base prompt to establish the 1–36 scale for writing. To obtain the base prompt raw-to-scale score conversion, percentile ranks of all raw score points (i.e., the sum of the four domain scores) were calculated. Then the corresponding z-scores from a standard normal distribution were obtained for these percentile ranks. The z-scores were then linearly transformed to cover the whole score range of 1–36. Finally, a seven-degree polynomial regression of the unrounded scale scores on the raw scores was used to slightly smooth the conversion prior to rounding to integer scale scores to obtain the final raw-to-scale score conversion for the base form.

Although prompts are selected to ensure to a large extent that the 2–12 overall writing scores are comparable no matter which prompt the student takes, that process does not ensure that these prompts are also strictly comparable on the sum of the domain scores (ranging from 8 to 48), which are converted to the 1–36 scores. Therefore equating methodology is used to adjust for slight differences in prompt difficulty that may still remain after the writing prompt selection process. The same methodology used for equating the multiple-choice ACT tests is used for equating each prompt to the 1–36 writing scale: equipercentile equating with postsmoothing under the randomly equivalent groups design. Consequently, students with the same English, reading, and writing 2–12 scores may have slightly different ELA scores if they took different writing prompts. This process ensures year-to-year comparability in the ELA scores that are based in part on the writing scores. The ELA score is intended to be a more reliable measure of student ability than the ACT writing prompt score, which is based on a student's response to a single prompt.

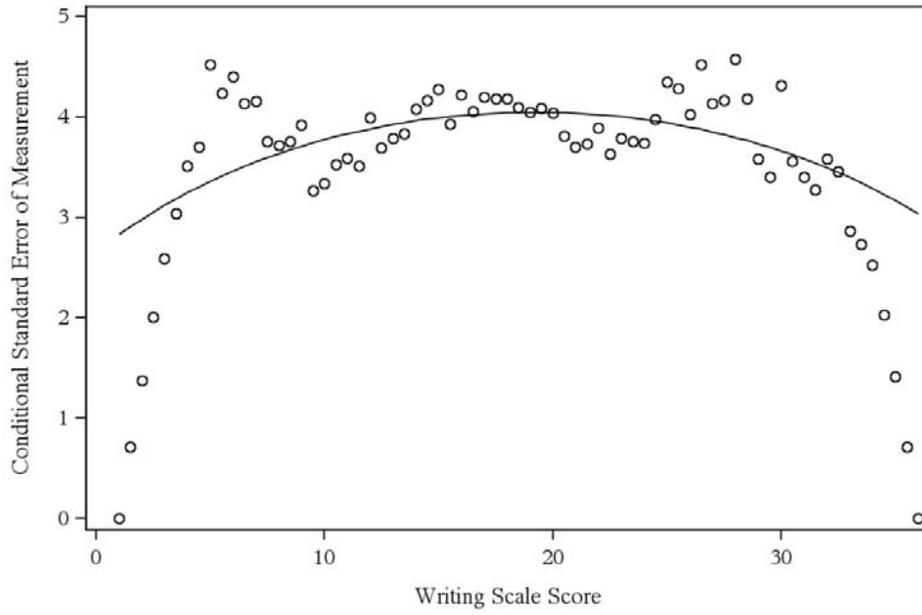
1.5.5. Writing Reliability and Standard Error of Measurement

To investigate the properties of the writing scores, a generalizability study was conducted in fall 2014. The study was separated into three different parts. Each part involved a different pair of schools. Within each pair of schools, two different writing prompts were used. The responses to both writing prompts were rated by three raters on the four different domains. The same raters rated both prompts for both schools. Different pairs of prompts and different groups of three raters were used for each pair of schools. This essentially served as three different replications of the same study design. A multivariate generalizability analysis was conducted for the domain scores based on a “person by prompt by rater” design. The estimated variance components for the interactions between both prompt and rater as well as person and rater were quite small across all three school pairs. The estimated variance components for the interaction between person and prompt were relatively large for all three pairs, however. This is consistent with results typically found in the literature. For the unrounded average of the domain scores, the generalizability coefficients (reliability-like estimates of score consistency) ranged from 0.61 to 0.77, which are fairly high for a writing assessment. Standard errors of measurement (SEMs) ranged from 0.84 to 1.1.

To estimate the reliability and SEM for writing scores on the 1–36 scale, data from the 2014 writing field test study were used. Each student took two different prompts. The data were analyzed using a person by occasion generalizability theory design. The individual conditional error variances were fit with a quadratic polynomial. The square root of these fitted values is represented by the black curve in Figure 1.2. The average conditional standard error of measurement (CSEM) values, represented by the circles, were calculated by taking the square root of the average conditional error variances at each scale score point. The generalizability coefficient was 0.68 and the SEM was 3.89. This SEM value was used in the calculation of the ELA reliabilities and SEMs.

Based on the same data set and using the same methodology, the reliability and SEM for the writing 2-12 rounded average domain scores were estimated. The generalizability coefficient was 0.66 and the SEM was 1.13.

Figure 1.2. Average and fitted CSEMs for writing scores.



CHAPTER 2

Additional Scores and Indicators

In September 2015, ACT began reporting Science, Technology, Engineering, and Mathematics (STEM) and English Language Arts (ELA) scores in addition to the four multiple-choice test scale scores and Composite scores. Understanding Complex Texts and Progress Toward the ACT National Career Readiness Certificate indicators were also first reported to students in 2015. This section presents information related to these scores and indicators.

2.1. STEM and ELA Scores

The STEM score is the average of the mathematics and science scale scores rounded to the nearest integer (fractions of 0.5 or greater round up). The ELA score is the average of the 1–36 scale scores for English, reading, and writing. Only students who receive scores for all three tests receive an ELA score. The STEM and ELA scores both range from 1 to 36.

Equating

STEM and ELA scores are not directly equated across forms. Because they are the average of scores that are equated across forms, STEM and ELA scores are comparable across forms. The same is also true for Composite scores.

Standard Error of Measurement and Reliability

STEM and ELA CSEMs were calculated with the same approach that is used for the calculation of Composite score CSEMs (for further details, see the *ACT Technical Manual*, ACT, 2014). Assuming the measurement errors on the individual tests are independent, the CSEM of the unrounded STEM score is

$$CSEM_{STEM}(\tau_m, \tau_s) = \frac{\sqrt{\sum_i CSEM_i^2(\tau_i)}}{2},$$

where $CSEM_i(\tau_i)$ is the CSEM for test i at true scale score τ_i , where $i = m$ and s for mathematics and science, respectively. Similarly, for the unrounded ELA scores, the CSEM is

$$CSEM_{ELA}(\tau_e, \tau_r, \tau_w) = \frac{\sqrt{\sum_i CSEM_i^2(\tau_i)}}{3},$$

where $i = e, r,$ and w for English, reading, and writing, respectively.

For each multiple-choice test (English, mathematics, reading, and science), CSEMs were computed for each student using the methods described in the *ACT Technical Manual* (ACT, 2014). The CSEMs for writing were from the person by occasion generalizability study described earlier. The individual CSEM values were fit with a quadratic polynomial. For calculation of the ELA CSEMs, students were assigned the fitted value for the CSEM corresponding to their observed score. The STEM and ELA CSEM plots are shown in Figures 2.1 and 2.2, respectively. The same methods for calculating the reliability and SEM for Composite scores were used for the STEM and ELA scores. STEM and ELA score descriptive statistics for students who participated in five of the 2015–2016 national administrations are shown in Table 2.1. and reliability and SEM values are presented in Table 2.2.

Table 2.1. Scale Score Summary Statistics of the ACT Test Scores for Five of the 2015–2016 National ACT Administrations

Statistic	English	Mathematics	Reading	Science	ELA	STEM	Composite
Mean	21.63	21.65	22.50	21.85	22.13	22.00	22.03
SD	6.38	5.36	6.11	5.14	5.39	4.97	5.22
Skewness	0.15	0.40	0.18	0.22	-0.09	0.33	0.22
Kurtosis	-0.57	-0.67	-0.69	0.10	-0.58	-0.41	-0.61

Table 2.2. Scale Score Reliability and Standard Error of Measurement Summary Statistics for Five of the 2015–2016 National ACT Administrations

Test	Reliability			SEM		
	Median	Minimum	Maximum	Median	Minimum	Maximum
English	0.92	0.92	0.93	1.71	1.67	1.74
Mathematics	0.91	0.90	0.92	1.55	1.45	1.63
Reading	0.87	0.85	0.88	2.16	2.07	2.27
Science	0.85	0.81	0.85	2.01	1.90	2.16
ELA	0.91	0.88	0.91	1.59	1.58	1.60
STEM	0.93	0.93	0.94	1.29	1.24	1.30
Composite	0.94	0.93	0.95	1.25	1.24	1.27

Figure 2.1. Conditional standard errors of measurement of the STEM scores for five of the forms used in 2015–2016 national ACT administrations.

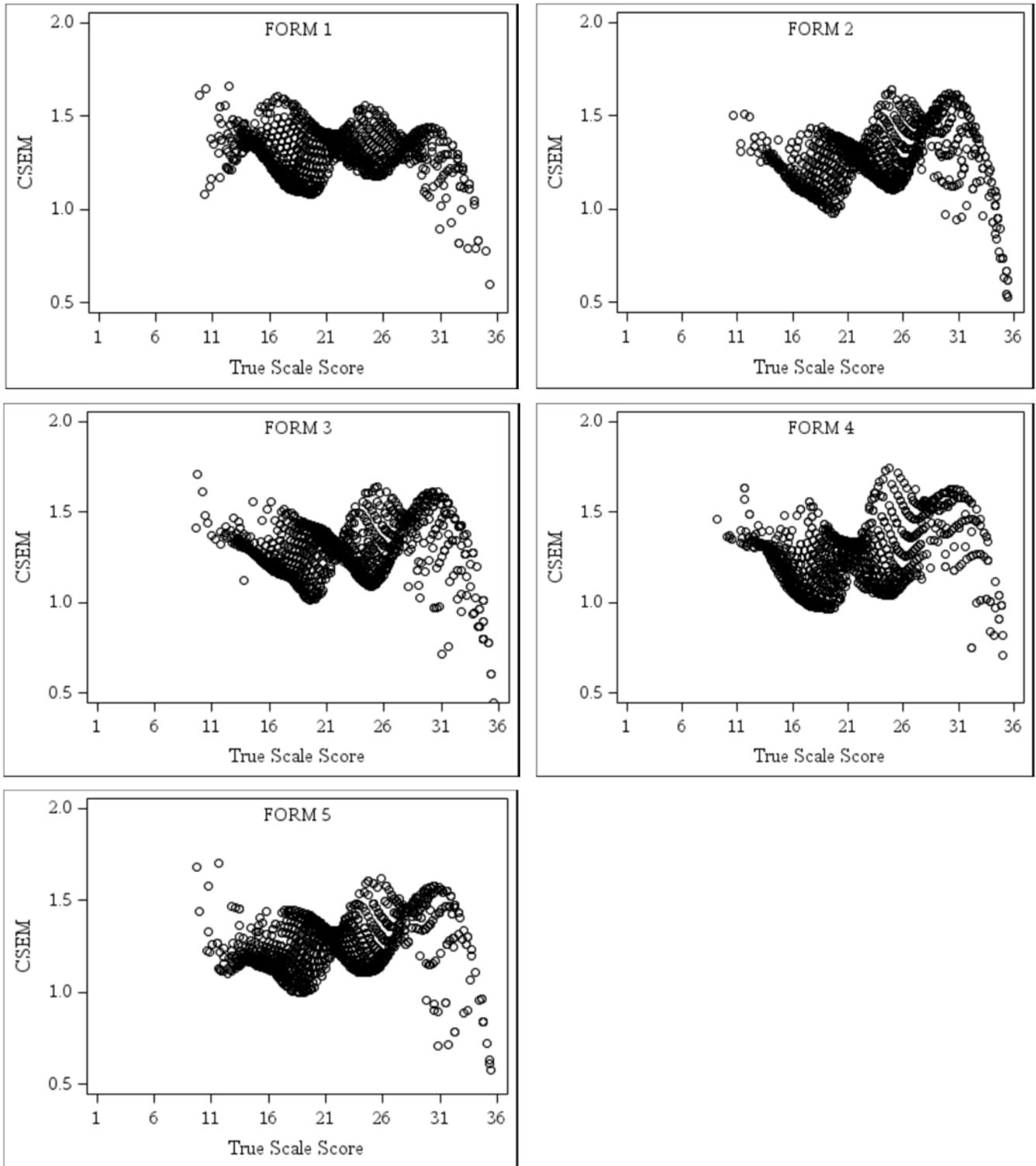
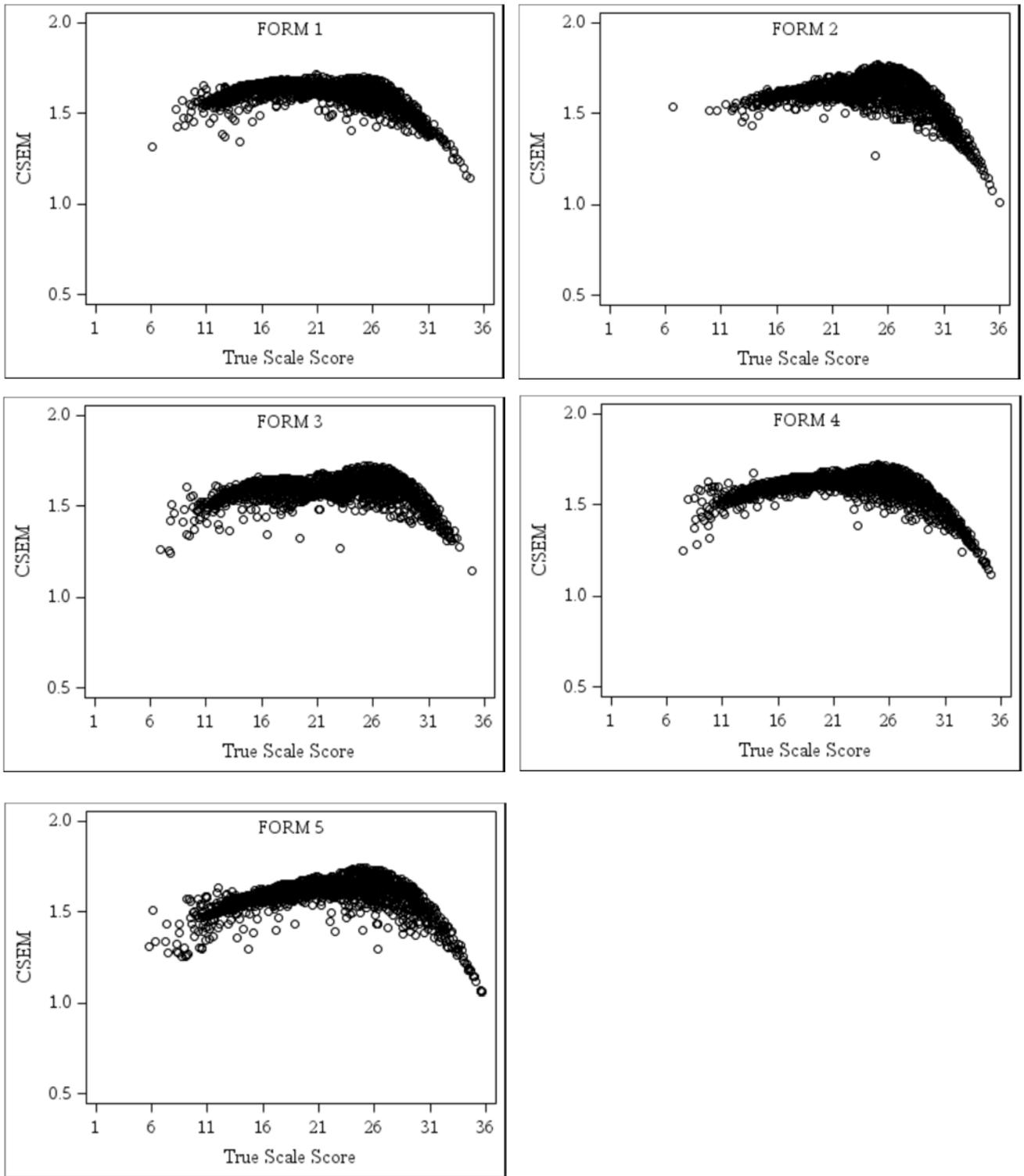


Figure 2.2. Conditional standard errors of measurement of the ELA scores for five of the forms used in 2015–2016 national ACT administrations.



Development of ACT's STEM Readiness Benchmark

In fall 2015, ACT introduced a STEM score for the ACT test that provides students and educators with more insight into critical aspects of students' readiness for first-year college coursework in science, technology, engineering, and mathematics (STEM) disciplines. The STEM score is the rounded average of the ACT mathematics and science test scores and represents students' overall performance in these subjects. A study by Mattern, Radunzel, and Westrick (2015) suggested that academic readiness for STEM coursework may require higher scores than those indicated by the ACT College Readiness Benchmarks given that Calculus instead of College Algebra appears to be the typical first mathematics course of students majoring in STEM. The typical first science course taken by students majoring in a STEM-related field included Chemistry, Biology, Physics, or Engineering. In a subsequent study, Radunzel, Mattern, Crouse, and Westrick (2015) identified the ACT STEM score that is associated with a reasonable chance of success in first-year STEM-identified mathematics and science courses.

- **Data and method.** Data used to develop the ACT STEM Readiness Benchmark based on the ACT STEM score came from four-year postsecondary institutions that had participated in research services offered by ACT and included students from the 2005 through 2009 freshman cohorts. Results were based on 22,246 students from 37 institutions for Calculus and 69,328 students from 70 institutions for the science courses. The same methodology as the single subject area ACT College Readiness Benchmarks was used to develop the ACT STEM Readiness Benchmark (Allen, 2013; Mattern et al., 2015). Briefly, the grades earned in first-year STEM courses (Calculus, Biology, Chemistry, Physics, and Engineering) were combined in a single course success model to determine the ACT STEM test score that was associated with at least a 50% chance of earning a B or higher grade in those courses. Hierarchical logistic regression was used to model within each college the probability of success in a course as a function of ACT STEM score. The model also included an indicator for content area (mathematics versus science). Typical probabilities of success by ACT STEM score were determined by first calculating the median probabilities across institutions within each content area and then averaging the probabilities across the two content areas giving equal weight to the two areas.
- **Results.** When combining grade data for Calculus and multiple science courses into a single course-success model, the ACT STEM score associated with at least a 50% chance of earning a B or higher grade in a STEM-related course was determined to be 26. Moreover, this cutoff score was also associated with an approximate 75% chance of earning a C or higher grade. The ACT STEM score of 26 also corresponded to the average of the ACT mathematics (27) and science (25) scores, which were derived by using separate STEM content area course-success models for Calculus and a combination of science courses (Mattern et al., 2015).
- **Summary.** The ACT STEM Readiness Benchmark can be used to help gauge overall student readiness for STEM-related coursework. Based on the ACT STEM Readiness Benchmark of 26, only 20% of the 2016 ACT-tested high school graduating class was ready for first-year STEM-related college courses.

Statistical Relationships between ACT STEM Scores and Students' Chances of Succeeding in a STEM-Related Major

A study by Radunzel et al. (2015) examined the ACT STEM score in relation to the likelihood of succeeding in a variety of STEM-related college outcomes: cumulative GPA over time, persistence in a STEM major, and ultimately completing a STEM degree.

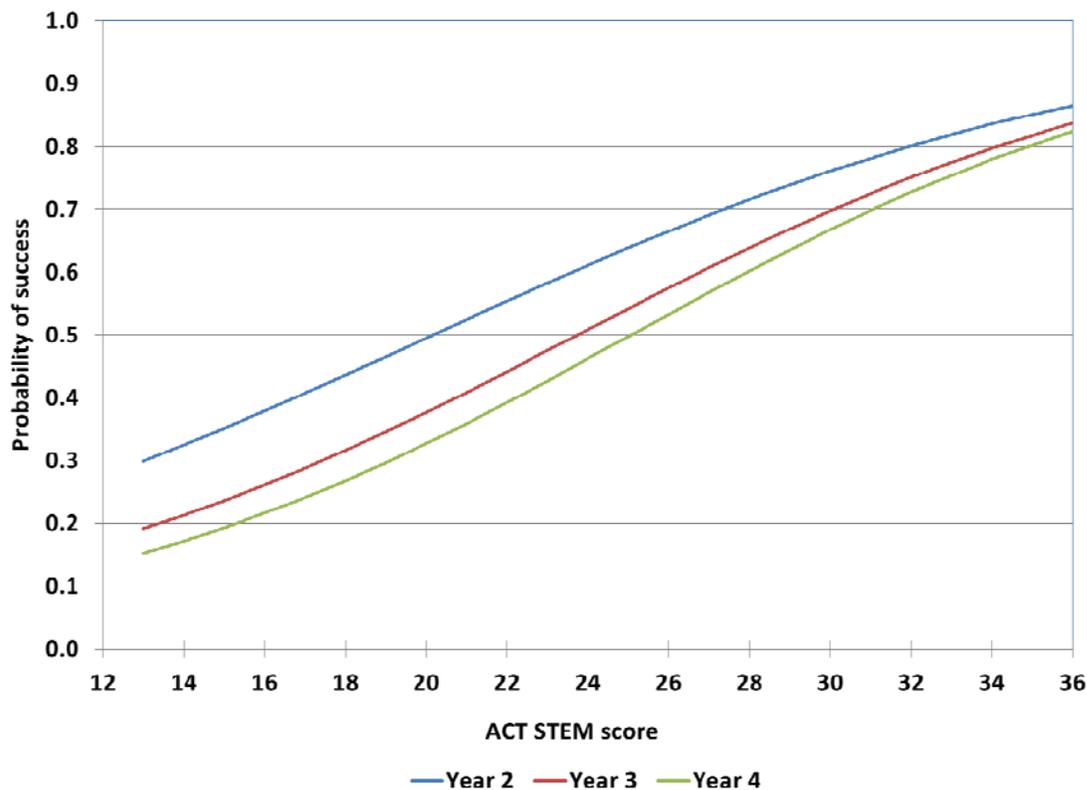
Data and method. Longitudinal college outcomes data used in the study were provided by both two- and four-year postsecondary institutions who had participated in research services offered by ACT. The study focused on students from the 2005 to 2009 freshman cohorts who declared a STEM major within their first year of college. College outcomes data for the four-year sample were available from 48 four-year institutions and included approximately 53,000 students majoring in STEM who were tracked primarily at the initial institution attended. College outcomes data for the two-year sample were based on more than 10,000 students majoring in STEM who first enrolled in one of 36 two-year institutions from two state systems. For the two-year sample, students were tracked across in-state two- and four-year postsecondary institutions, so in-state transfer information was available.

Due to the nested structure of the data, various hierarchical regression models were used to estimate students' chances of succeeding in a STEM major at a typical institution. Success rates were estimated using the fixed-effect parameter estimates from the hierarchical regression models. Specifically, logistic regression was used to estimate students' chances of earning a cumulative GPA of 3.0 or higher, multinomial regression was used for students' chances of persisting in a STEM major, and discrete-time survival regression was used for students' chances of completing a degree in a STEM-related field. For the four-year sample, completion of a bachelor's degree within 4, 5, or 6 years was evaluated. For the two-year sample, completion of an associate's or bachelor's degree was evaluated. For more details on the data and methods used, see the full report (Radunzel et al., 2015).

- **Results.** ACT STEM scores are positively related to students' chances of achieving specific cumulative GPAs over time, persisting in a STEM major over time, and completing a degree in a STEM field (Radunzel et al., 2015). These findings hold for students who began at both two- and four-year postsecondary institutions, as well as for students in each of the four STEM major clusters (Computer Science & Mathematics, Engineering, Medical & Health, and Science). Figure 2.3 provides the results for STEM persistence at years 2, 3, and 4 for students majoring in STEM who began at a four-year institution. The chances of persisting in a STEM major are 67% at year 2, 57% at year 3, and 53% at year 4 for students with an ACT STEM score of 26. Students with STEM scores above 26 have even greater chances of success. In comparison to those with a score of 26, students' chances are 12 to 14 percentage points lower across the years for those with an ACT STEM score of 22 (55%, 44%, and 39%, respectively). Moreover, students majoring in STEM with an ACT STEM score of 26 or higher were nearly three times more likely than those with a score of 22 or below to earn a STEM bachelor's degree within six years (49% vs. 17%). Only one-third of students majoring in STEM with an ACT STEM score between 23 and 25 completed a STEM bachelor's degree by the end of year 6. For additional figures illustrating the relationships between the ACT STEM score and students' chances of succeeding in a STEM major, see the full report (Radunzel et al., 2015).

- Summary.** The results from the study illustrate that predicting student success in STEM-related fields is a valid use of the ACT STEM score. Another study by Radunzel, Mattern, and Westrick (2016) suggested that the positive relationship between ACT STEM scores and students' chances of succeeding in a STEM major hold even after statistically controlling for other student characteristics, such as their high school coursework taken and grades earned in those courses, their vocational interests, and their demographic characteristics. This finding is consistent with a growing body of literature that has found educational success is a product of not only academic skills and knowledge but also of noncognitive factors such as motivation, academic goals, and academic self-efficacy (Mattern, Burrus, Camara, O'Connor, Hanson, Gambrell, Casillas, & Bobek, 2014).

Figure 2.3. Probability of persisting in a STEM major at years 2, 3, and 4 by ACT STEM score at a typical four-year institution.



2.2. Understanding Complex Texts

Beginning in September 2015, ACT test score reports have included an indicator for Understanding Complex Texts (UCT) to show whether students are understanding the central meaning of complex texts at a level that is needed to succeed in college courses with higher reading demand. This indicator is based on scores from a subset of items on the reading test. These items measure students' global comprehension of the passages instead of sentence- or word-level understanding. Student performance on these items is classified into three performance levels: Below Proficient, Proficient, and Above Proficient.

The performance levels were established through a special study that linked students' scores on the UCT items to their college course grades (Allen, Bolender, Fang, Li, & Thompson, 2016). Because UCT scores were not reported for earlier ACT test forms, the UCT test items were classified retroactively for each form so that students' number correct UCT scores could be calculated. The number of items that contributed to the UCT score varied across forms. The number correct UCT scores were then equated across forms to an interim score scale ranging from 0 to 16.

The development of the cut scores for Proficient and Above Proficient was described by Allen et al. (2016). This special study examined the UCT scores and course grades of 263,265 students from 439 postsecondary institutions and found that the UCT scores were more predictive of success in college courses that have higher demand for understanding complex texts. Hierarchical logistic regression using UCT scores was used to predict students' chances of earning a B or higher in seven types of courses (American History*, Literature, Other History*, Other National Science, Physics (without Calculus), Sociology, and Zoology*). Three of the seven course types (marked with *) were also used to develop the ACT College Readiness Benchmark for the reading test. For each course and institution, the UCT score associated with a 50% chance of earning a B or higher was identified. These results were aggregated over a weighted sample of institutions to find the Proficient cut score of 9. This score is associated with a 50% chance of earning a B or higher at a typical institution. The Proficient cut score is also associated with a 78% chance of earning a C or higher grade and a 22% chance of earning an A.

The Above Proficient cut score of 13 was found in a similar way. This score is associated with a 67% chance of earning a B or higher at a typical institution. The Above Proficient cut score is also associated with an 85% chance of earning a C or higher grade and a 37% chance of earning an A. The Above Proficient cut score is about two standard errors of measurement above the Proficient cut score. For additional information on the development of the UCT cut scores, see the full report by Allen et al. (2016).

UCT number correct raw scores on operational forms are all equated to the interim score scale so the UCT performance levels can be interpreted consistently across forms. The classification index for these scores is described in the next section.

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 a four-parameter beta distribution. The expected conditional distribution of scores, given the true score, is a binomial distribution. With the assumption of independent errors of measurement, the probabilities that a student would be classified into each pair of categories were computed, given the true score. 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 diagonals of the contingency table, which represent the probabilities of being classified in the same category on two separate administrations.

Classification consistency was computed for five of the forms used in the 2015–2016 national ACT administrations. Across forms, the classification consistency ranged from .64 to .69, which was moderately high considering the number of items that contribute to UCT scores and the number of performance levels. The number of UCT items ranged from 16 to 21 across these five forms, and the percent of students classified as Below Proficient, Proficient, and Above Proficient across the five administrations in 2015-2016 was 43%, 33%, and 24%, respectively.

2.3. Progress Toward the ACT National Career Readiness Certificate

The Progress Toward the ACT National Career Readiness Certificate indicator is based on students' ACT Composite scores and provides an estimate of future achievement on the ACT National Career Readiness Certificate™ (ACT NCRC®). The ACT NCRC is an assessment-based credential that certifies foundational work skills important for job success across industries and occupations. The ACT NCRC is based on the results of three ACT WorkKeys® assessments: Applied Mathematics, Locating Information, and Reading for Information. Scores on these 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 ACT NCRC can be found at <http://workforce.act.org/credential>.

Data from over 110,000 grade 11 students who took both ACT WorkKeys (and obtained the ACT NCRC) and the ACT were used to establish a link between ACT Composite scores and the ACT NCRC levels. Because the constructs and content of the ACT test differ from that of ACT WorkKeys, logistic regression was used to predict the ACT Composite cut score that corresponded to a 50% chance of obtaining each ACT NCRC level. This method of determining cut scores was similar to the approach used to establish the ACT College Readiness Benchmarks (e.g., Allen, 2013). The study showed that the ACT Composite Scores corresponding to the Bronze, Silver, Gold, and Platinum certificates were 13, 17, 25, and 35, respectively.

Based on the ACT Composite cut scores obtained for each NCRC level from the linkage study, the Progress Toward ACT NCRC indicator classifies students into one of four levels: Making Insufficient Progress Toward a Certificate, Progress Toward Bronze Level NCRC, Progress Toward Silver Level NCRC, and Progress Toward Gold Level NCRC.

If a student's ACT Composite score surpassed the cut score for an NCRC level, the student is categorized as making progress toward the next higher NCRC level. The ranges of the ACT Composite scores for each level are shown in Table 2.3. Because of the small proportion of students obtaining a Platinum level, the highest level reported for this indicator is Gold. Note that the Progress Toward ACT NCRC indicator is not a prediction of students' likely attainment of an NCRC level, but an indicator of the NCRC level that a student is likely progressing toward. For a comparison of the Progress Toward ACT NCRC results and predicted NCRC level results for the 2016 ACT-tested high school graduating class, see a technical brief by Allen, LeFebvre, and Mattern (2016).

Classification Consistency

Classification consistencies of the Progress Toward ACT NCRC indicator were calculated for five of the forms used in the 2015–16 national administrations. The classification consistency index ranged from 0.87 to 0.93. Classification consistency of the Progress Toward ACT NCRC indicator was calculated using the same approach used to calculate the classification consistency of the Understanding Complex Texts indicator. Note that the classification consistency index is an indication of the stability of Progress Toward ACT NCRC indicator if different ACT test forms were taken and is not an indication of the accuracy of the classification compared with students’ actual NCRC attainment.

The Progress Toward ACT NCRC indicator is not a substitute for an actual ACT NCRC level obtained by taking ACT WorkKeys. Actual performance could differ from the statistically predicted performance for a variety of reasons, including differences in the ACT test and ACT WorkKeys test, statistical uncertainty in the prediction, and a student’s growth trajectory.

Table 2.3. Composite Score Ranges for the ACT NCRC Levels

ACT NCRC Level	Composite Score Range
Making Insufficient Progress Toward a Certificate	1–11
Progress Toward Bronze	12–13
Progress Toward Silver	14–17
Progress Toward Gold	18–36

2.4 Interest-Major Fit

The ACT Student, High School, and College Reports display the student’s level of interest-major fit. This fit level is derived from two data elements collected from students during ACT registration: the student’s ACT Interest Inventory scores and the major they plan to enter. Interest–major fit measures the strength of the relationship between the individual student’s profile of ACT Interest Inventory scores and the interest profile of students in the planned major. Interest profiles for each of the 294 majors on the ACT registration list are based on a large sample of undergraduate students (from 73 institutions in 21 states) with a declared major and a GPA of at least 2.0. Major was determined in the third year for students in 4-year colleges and in the second year for students in 2-year colleges.

The interest-major fit level is based on an interest–major fit score. Although not shown on these reports, fit scores range from 00 to 99. The higher the score, the better the interest–major fit. Using data from a large sample (collected from 42 institutions in 16 states), three levels of fit were established based on the empirical relationships between interest-major fit scores and the proportion of students who persisted in their college major. The first cut score was set at 60 because the relationship between fit scores and major persistence was relatively flat for scores below 60. The relationship between fit scores and college major persistence rates displayed a steady increase above 60; therefore, the second cut score was set at the midpoint (80) of the

first cut score and the maximum possible score. Data from the same sample indicated that students were approximately evenly distributed across the three levels: 37% in High, 31% in Medium, and 32% in Low. Level of interest-major fit is displayed on the Student, High School, and College score reports as shading of one of the three (Low, Medium, High) sections of the interest-major fit bar.

The concept of fit is foundational to understanding how people transition across and within social environments (Holland, 1997; Kristof-Brown & Guay, 2011). While frequently used to understand the relationship between a person and a work environment (e.g., in career planning), the concept of fit is equally important in academic environments, such as college majors. Different college majors and programs of study have different academic cultures. These academic cultures emphasize different tasks and skills, and many students gravitate toward majors or programs that match their own personal attributes. For example, students are more likely to select a major if it fits their interests (Porter & Umbach, 2006; Smart, Feldman, & Ethington, 2000).

Of the many ways that people can potentially fit their major, focusing on interests is particularly relevant. Interests are motivational and play a role in both initiating and sustaining behavior (Silvia, 2006). In academic settings interest in an activity or content area influences important behaviors such as attention (e.g., Hidi, Renninger, & Krapp, 2004), persistence, (e.g., Krapp & Lewalter, 2001), goal setting (e.g., Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008), and academic achievement (e.g., Denissen, Zarrett, & Eccles, 2007). Further, there is growing evidence that the fit between students' interests and their college majors is important in understanding and predicting student outcomes. Research involving the ACT Interest Inventory suggests that if students' measured interests (i.e., patterns of scores on interest inventories) are similar to the interests of people in their chosen college majors, they will be more likely to persist in college (Tracey & Robbins, 2006; Allen & Robbins, 2008), remain in their major (Allen & Robbins, 2008), and complete their college degree in a timely manner (Allen & Robbins, 2010). Even before students declare a major in college, fit between their interests and planned major is a good predictor of whether they will follow through on their college major plans (ACT, 2013).

More broadly, the value of interest-major fit is not limited to the ACT Interest Inventory or to the outcomes listed above. A large-scale meta-analysis, involving data over a 60-year time period and including a range of outcome and interest measures (including the ACT Interest Inventory), found that interest-environment fit is related to persistence and performance in both academic and work settings (Nye, Su, Rounds, & Drasgow, 2012). Additional information on research involving the ACT Interest Inventory and interest-major fit is described in ACT (2009).

Learn more about interest-major fit and view data in an interactive format at the following website – [College Choice Report—Part 2: Enrollment Patterns \(ACT, 2013\)](#).

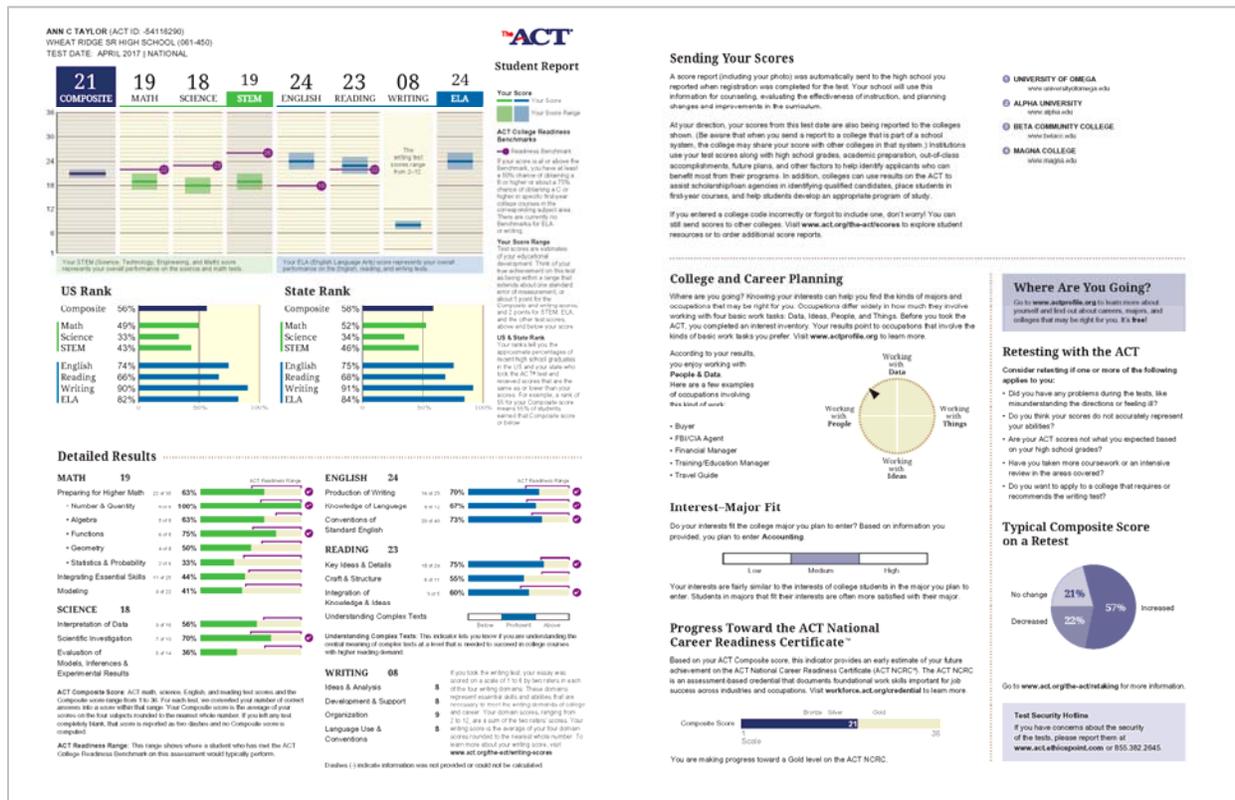
CHAPTER 3

College and Career Planning Information on ACT Score Reports

This chapter briefly describes selected elements related to college and career planning that are found on the enhanced student, high school, and college score reports. These reports allow students and educators to better navigate results and gain more meaningful insights. New measures such as Interest-Major Fit and Progress Toward the ACT National Career Readiness Certificate assist students and their counselors in charting the path to college and career.

ACT has provided training and new support materials to assist schools and districts in using these new reports. Chapter 3 of The ACT Test User Handbook for Educators provides descriptions for all the sections included on the enhanced ACT score reports. The User Handbook can be found at: <http://www.act.org/content/dam/act/unsecured/documents/ACT-UserHandbook.pdf>.

Figure 3.1 2016-17 ACT sample student report



3.1 Student Report

College and Career Planning

This section of the student score report provides a visual summary of the results of the ACT Interest Inventory. The Career Connector is a two-dimensional figure with four compass points. The compass points are four basic work tasks shown to underlie the work done in all occupations: Working with People, Data, Things, and Ideas (ACT, 2009). The Career Connector summarizes the pattern of results from the scales on the ACT Interest Inventory and visually displays it as one or two directions with respect to these compass points. As currently used on the ACT Student Report, the Career Connector also includes a personalized list of five occupations that involve work tasks in this same direction.

The Career Connector is derived from ACT's Career Map, an empirically based system for summarizing basic similarities and differences between groups of occupations with respect to their relative involvement with people, data, things, and ideas. The Career Map serves as an interpretive bridge linking people to occupations and is designed to engage users in the process of career exploration. Both the Career Map and the Career Connector are grounded in research involving extensive and diverse occupational data based on expert ratings, job analyses, and measured interests (ACT, 2009; Prediger & Swaney, 2004).

In sum, the Career Connector serves two roles. First, it visually displays a summary of the basic work-relevant interests of the student. Second, it provides an introduction to the concepts that

serve as the foundation for ACT's Career Map. Thus the Career Connector, while not a map itself, summarizes the interest inventory results and helps to prepare students to understand and use the Career Map to explore personally relevant career options.

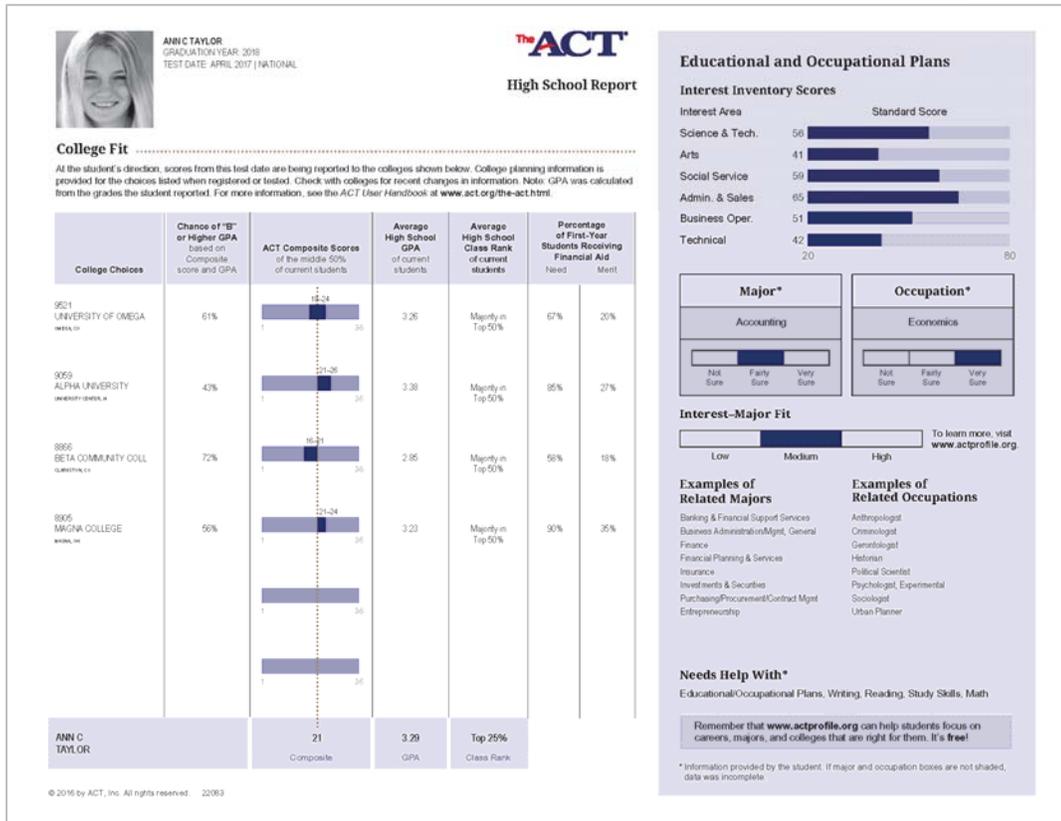
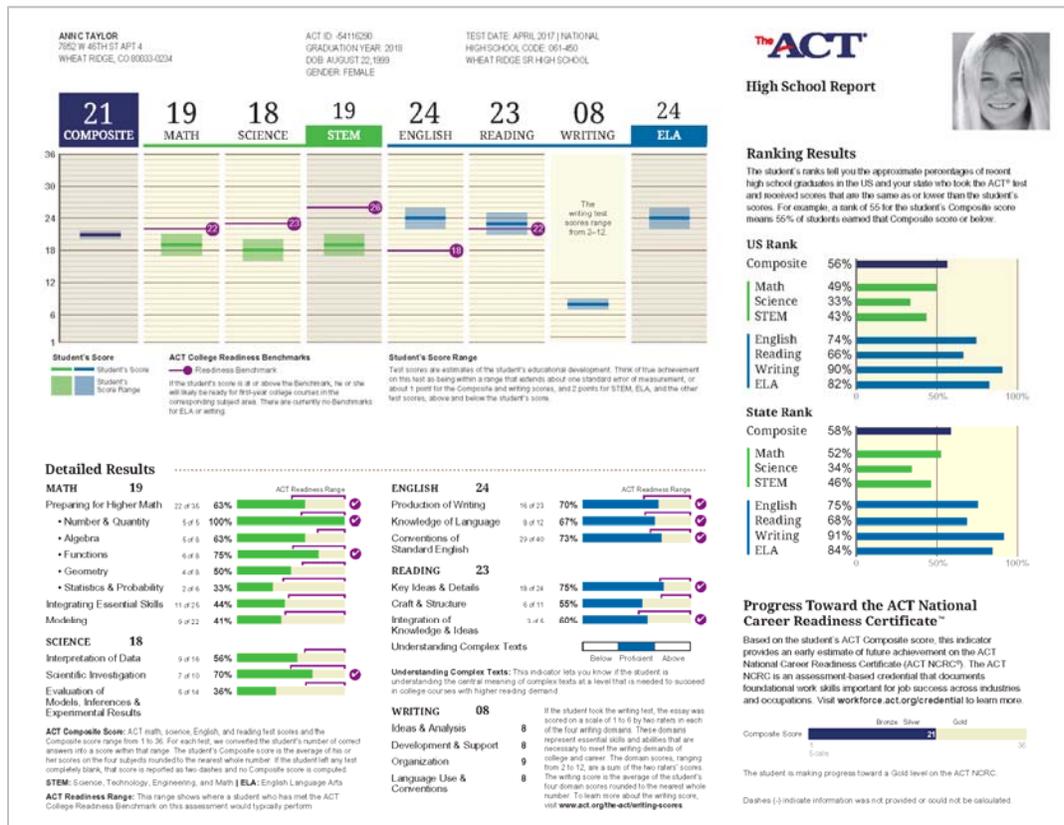
Interest-Major Fit

The ACT Student Report lists the student's planned college major and displays the level of interest-major fit. The latter is shown by shading in one of the three sections (Low, Medium, High) of the interest-major fit bar. The fit level is derived from two data elements: the student's ACT Interest Inventory scores and the self-reported major the student plans to enter. These elements are used to calculate an interest–major fit score, which is converted to one of three fit levels to summarize the strength of the relationship between the student's interests and the interests of students in the planned major. Interest-major fit is described in more detail in section 2.4.

Progress Toward the ACT National Career Readiness Certificate

This section of the report provides Progress Toward the ACT National Career Readiness Certificate™ indicator based on students' Composite score. This is an indicator of future performance on the ACT National Career Readiness Certificate™ (ACT NCRC®). The ACT NCRC is an assessment-based credential that certifies foundational work skills important for job success across industries and occupations. The Progress toward Career Readiness indicator suggests whether a student is making sufficient progress toward one of the following NCRC levels: Bronze, Silver, or Gold.

Figure 3.2 2016-17 ACT sample high school report



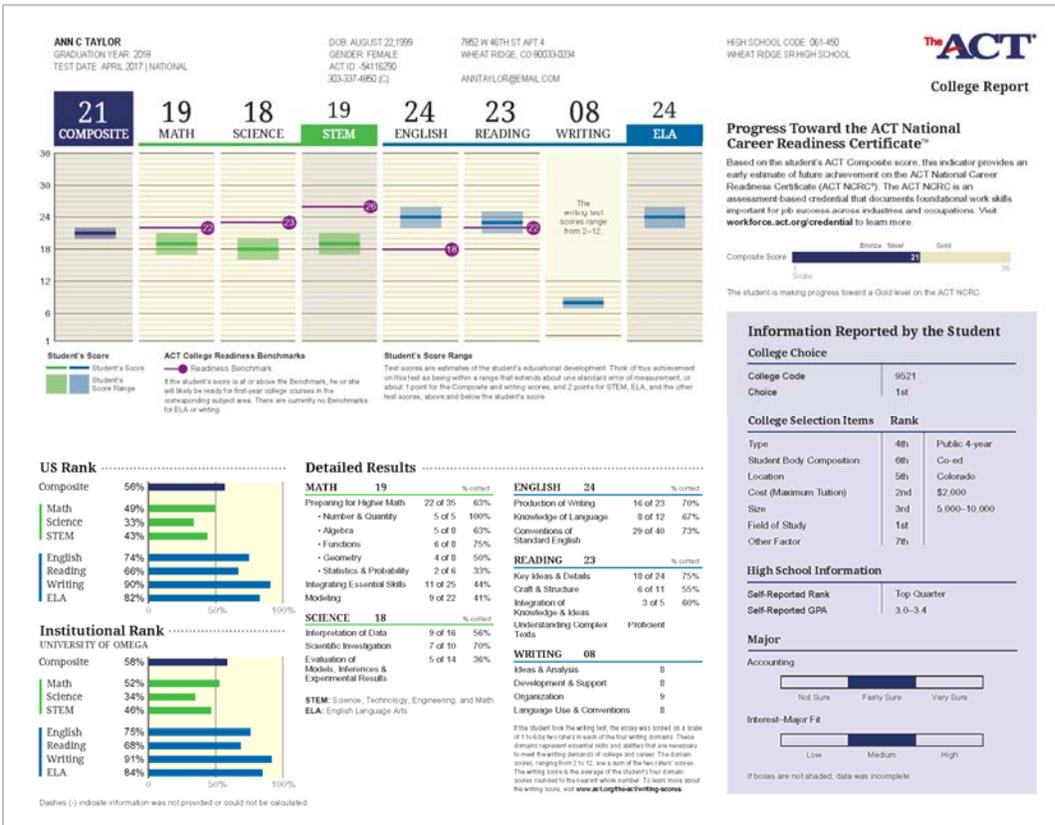
3.2 High School Report

Educational and Occupational Plans

This section of the ACT High School Report consists of five parts (see Figure 3.2): (1) ACT Interest Inventory scores, (2) the student's self-reported choice of major and occupation accompanied by their level of certainty about that choice, (3) interest-major fit, (4) examples of majors related to their major choice and occupations related to their occupation choice, and (5) a list of the educational areas (e.g., writing) the student reported needing help with. Each of the five parts is based (directly or indirectly) on self-reported information collected from students during ACT registration. These five parts are described in turn.

- **ACT Interest Inventory scores.** The ACT Interest Inventory scores are reported as standard scores (Mean=50, SD=10) based on Grade 12 nationally representative norms involving over 250,000 students from over 8,000 schools (ACT, 2009). Reliability and validity of the ACT Interest Inventory for career exploration and planning are well established (ACT, 2009). These scores are made available for counselors who are familiar with Holland's theory of career types (Holland, 1997) and may want to use these scores to offer a clinical interpretation of the student's interests.
- **Major and occupation choice.** The ACT High School Report lists the student's planned college major and first choice of occupation. Also shown is the student's self-reported level of certainty (Not Sure, Fairly Sure, Very Sure) for both their current choice of major and occupation. Level of certainty has been found to be highly related to persistence of choice from planned major in high school to declared major in college (ACT, 2013).
- **Interest-major fit.** The high school score report displays the student's level of interest-major fit, shown by shading in one of the three sections (Low, Medium, High) of the interest-major fit bar. The fit level is derived from two data elements: the student's ACT Interest Inventory scores and the self-reported major the student plans to enter. These elements are used to calculate an interest-major fit score, which is converted to one of three fit levels to summarize the strength of the relationship between the student's interests and the interests of students in the planned major. Interest-major fit is described in more detail in section 2.4.
- **Example majors and occupations.** This part lists up to eight majors related to the student's major they plan to enter and up to eight occupations related to their first occupational choice. Many students consider several possibilities before making definite career plans. These lists can be used as a starting point for considering other possibilities to explore.
- **Needs help with.** This is a list of educational areas the student reported needing help with. The student responds yes or no to each of the five areas listed in the Student Profile Section (SPS) of the ACT: educational/occupational plans, writing, reading, study skills, and math.

Figure 3.3 2016-17 ACT sample college report



ANN C TAYLOR
GRADUATION YEAR: 2019
TEST DATE: APRIL 2017 (NATIONAL)

DOB: AUGUST 22, 1999
GENDER: FEMALE
ACT ID: 54116250
303-337-4650 (C)

7952 W 46TH ST APT 4
WHEAT RIDGE, CO 80033-0234
ANN.TAYLOR@EMAIL.COM

HIGH SCHOOL CODE: 061-450
WHEAT RIDGE SR HIGH SCHOOL

The ACT
College Report

Information Reported by the Student

High School Information

Year H.S. graduation or equivalent	2018
Size of senior class	200-399
Type of school	Public
Type of program studied	College Prep

Background Information

Racial/Ethnic background	White
Religious preference	Prefer not to respond
English most frequently spoken in home	Yes
Mother/Guardian 1 ed. level	Bachelor's Degree (4 yrs)
Father/Guardian 2 ed. level	Some college, no degree

Subjects Studied

Subjects Studied	Years	GPA	AP
English	4	3.7	Yes
Math	4	3.1	No
Social Studies	3	3.5	Yes
Natural Sciences	3	2.9	No
Foreign Language			No
Spanish	1	N/A	
German	1	N/A	
French	0	N/A	
Other	0		N/A

Financial Aid Information

Plans to seek financial aid	Yes
Needs help to find work	Yes
Hours per week	11-20

Admissions/Enrollment Data

Full-time	Yes
Housing plans	Residence Hall
Citizenship status	Yes
Legal resident of mailing address state	Yes
Physical/Learning disability	No

Extracurricular Activities

Extracurricular Activities	High School	College
Instrumental Music	Yes	Yes
Vocal Music	No	No
Student Government	Yes	No
Publications	Yes	No
Debate	Yes	Yes
Dramatics	Yes	Yes
Religious Organizations	No	No
Racial/Ethnic Organizations	No	No
Varsity Athletics	Yes	No
Political Organizations	Yes	Yes
Radio/TV	No	No
Fraternity/Sorority/Social	No	No
Service Organizations	No	No

Chances of Success at UNIVERSITY OF OMEGA

Overall GPA

Student Group	Chance ≥ B	Chance ≥ C
First-Time Students	49%	83%
Business Admin	45%	81%
Liberal Arts	46%	86%
Engineering	57%	88%
Education	38%	79%

Specific Course Grade

Course	Chance ≥ B	Chance ≥ C
English Composition	89%	95%
College Algebra	20%	62%
History	67%	87%
Chemistry	11%	39%
Psychology	72%	92%

Chances of success are reported for ACT Research Services participants.

For more information about Chances of Success and how your institution can participate, please visit www.act.org/research.html or email research.services@act.org

© 2016 by ACT, Inc. All rights reserved. 22083

3.3 College Report

College and Career Planning Information

Among the categories of information related to college and career planning on the College Report (see Figure 3.3), three are described below.

- **Major choice.** The ACT College Report lists the student's planned college major and displays the student's level of certainty (Not Sure, Fairly Sure, Very Sure) for that major. Level of certainty has been found to be highly related to persistence of choice from planned major in high school to declared major in college (ACT, 2013).
- **Interest-major fit.** The college score report displays the student's level of interest-major fit, shown by shading in one of the three sections (Low, Medium, High) of the interest-major fit bar. The fit level is derived from two data elements: the student's ACT Interest Inventory scores and the self-reported major the student plans to enter. These elements are used to calculate an interest–major fit score, which is converted to one of three fit levels to summarize the strength of the relationship between the student's interests and the interests of students in the planned major. Interest-major fit is described in more detail in section 2.4.
- **Needs help with.** This is a list of educational areas the student reported needing help with. The student responds yes or no to each of the five areas listed in the SPS of the ACT: educational/occupational plans, writing, reading, study skills, and math.

CHAPTER 4

Online Testing and Mode Comparability

4.1 ACT Online Test Administration

ACT piloted the first-ever online administration of a national undergraduate college admission exam in April 2014. This pilot included college-reportable scores and was administered to approximately 4,000 students at 80 test sites in April 2014.

In April 2015, online testing was expanded to a limited number of state and district test sites with more than 6,000 students receiving college reportable scores. Online testing for the ACT was offered to all state and district sites in 2016 and will continue to be offered going forward.

Today, the ACT may be administered on paper or online. The ACT administered online is the same test as the paper version, but presented in an online delivery format. The ACT online test is delivered in testing windows, which are designed to provide access over a short period of time and to accommodate makeup and emergency situations. Online administration of the ACT follows the administration guidelines established for paper testing, where appropriate.

4.2 Online Platform and Capabilities

ACT collaborated with Pearson to design the platform architecture for administering the ACT online test delivery system. Test centers can use this test delivery system across multiple forms of technology (such as operating systems, platforms, and devices), including Macintosh® or PC. The minimum test delivery system requirements are continually updated to ensure compatibility with test delivery technology.

The most current technical requirements for taking the ACT online are available at:

<http://www.act.org/content/dam/act/unsecured/documents/TechnicalGuidefortheACTTakenOnline.pdf>

4.3 Comparability of Scores from Online and Paper Testing

To examine the comparability of scores between online and paper administrations, ACT conducted three special studies, including a timing study in fall 2013, a mode comparability study in spring 2014, and a second mode comparability study in spring 2015.

A randomly equivalent groups design was used for all of these studies. Students were randomly assigned to take the test under different timing conditions in the online timing study and were randomly assigned to take the paper or online test in both mode studies. Timing recommendations from the timing study were re-evaluated in the subsequent mode study, which resulted in a modification of the timing for the online administration. The updated timing for online administration was then implemented in the second mode study. See Li, Yi, and Harris (2016) for more details about these studies.

4.3.1 Fall 2013 Timing Study

The purpose of the timing study was to evaluate whether the online administration of the ACT would require time limits that differed from the paper administration. The four tests were administered online to approximately 3,000 examinees, with each examinee taking one test. Students were randomly assigned to take the test under one of the three timing conditions: the current paper time limit, the current time limit plus five minutes, and the current time limit plus ten minutes. At the end of the test, the students were also given a survey with questions regarding their testing experience, including whether or not they felt they had enough time to finish the test. Students in this study did not receive college reportable scores.

Item and test level scores, item omission rates, item and test latency information, and student survey results were analyzed using a variety of methods, both descriptive and inferential. Based on the timing study results, ACT decided to tentatively add five minutes for online administration of the reading and science tests. The timing decision was to be further investigated in subsequent studies.

4.3.2 Spring 2014 and Spring 2015 Mode Comparability Studies

To gather additional information about the differences across modes and to learn about potential administration issues, ACT conducted mode comparability studies in operational testing environments where, due to the study design, participating students received college-reportable scores.

More than 7,000 students from about 80 schools across the country signed up for the 2014 mode comparability study. Analyses were conducted to investigate two aspects of mode comparability: score equivalency and construct equivalency. Results showed that although little difference was found between the groups of randomly equivalent students testing in the two modes in terms of test reliability, correlations among tests, effective weights, and factor structure, test scores tended to be higher and omission rates tended to be lower for the online group than for the paper group, especially for the reading and science tests. Equating methodology was used for all four multiple-choice tests to adjust for the differences to ensure that the college-reportable scores from the mode comparability study were comparable to those from national test takers. Based on the findings from the spring 2014 study, ACT decided to eliminate the extra five minutes for the online reading and science tests. Refinements in the delivery of the online assessments may be one of the factors that contributed to the different recommendations of online test time limits from the timing study and the mode comparability study.

The spring 2015 mode comparability study was conducted to further examine the comparability between online and paper scores and the impact of eliminating the extra five minutes for the reading and science

ONLINE TESTING AND MODE COMPARABILITY

online tests. Over 4,000 students from more than 40 schools signed up to participate in this study. The data collection design and statistical analyses were the same as those in the 2014 mode comparability study. Results showed that students from randomly equivalent groups performed similarly across modes on the science test, but performed better on the online reading test even without the extra five minutes. Equating methodology was applied to produce comparable scores regardless of the testing mode.

CHAPTER 5

References

- ACT, Inc. (2009). *The ACT interest inventory technical manual*. Retrieved from <http://www.act.org/content/dam/act/unsecured/documents/ACTInterestInventoryTechnicalManual.pdf>
- ACT (2013). *College Choice Report Part 3: Persistence and Transfer*. Iowa City, IA: ACT.
- ACT, Inc. (2014). *ACT Technical Manual*. Iowa City, IA: author.
- Allen, J. (2013). *Updating the ACT College Readiness Benchmarks* (ACT Research Report No. 2013-6). Iowa City, IA: ACT, Inc.
- Allen, J., Bolender, B., Fang, Y., Li, D., & Thompson, T. (2016). *Relating the ACT indicator understanding complex texts to college course grades* (ACT Research & Policy Technical Brief). Iowa City, IA: ACT, Inc.
- Allen, J., LeFebvre, M., & Mattern, K. (2016). *Predicted attainment of ACT National Career Readiness Certificates for the 2016 ACT-tested high school cohort* (ACT Research & Policy Technical Brief). Iowa City, IA: ACT, Inc.
- Allen, J., & Robbins, S. B. (2008). Prediction of college major persistence based on vocational interests, academic preparation, and first-year academic performance. *Research in Higher Education, 49*, 62–79.
- Allen, J., & Robbins, S. (2010). Effects of interest-major congruence, motivation, and academic performance on timely degree attainment. *Journal of Counseling Psychology, 57*, 23–35.
- Denissen, J., Zarrett, N., & Eccles, J. (2007). I like to do it, I'm able, and I know I am: Longitudinal couplings between domain-specific achievement, self-concept, and interest. *Child Development, 78*, 430-447.
- Hanson, B. A., & Brennan, R. L. (1990). An investigation of classification consistency indexes estimated under alternative strong true score models. *Journal of Educational Measurement, 27*(4), 345–359.

REFERENCES

- Harackiewicz, J., Durik, A., Barron, K., Linnenbrink-Garcia, L. & Tauer, J. (2008). The role of achievement goals in the development of interest: Reciprocal relations between achievement goals, interest, and performance. *Journal of Educational Psychology, 100*, 105–122.
- Hidi, S., Renninger, K., & Krapp, A. (2004). Interest, a motivational variable that combines affective and cognitive functioning. In D. Y. Dai & R. J. Sternberg (Eds.), *Motivation, emotion, and cognition: Integrative perspectives on intellectual functioning and development* (pp. 89–115). Mahwah, NJ: Lawrence Erlbaum.
- Holland, J. L. (1997). *Making vocational choices (3rd ed.)*. Odessa, FL: Psychological Assessment Resources.
- Krapp, A., & Lewalter, D. (2001). Development of interests and interest-based motivational orientations. A longitudinal study in school and work settings. In S. Volet & S. Jarvela (Eds.), *Motivation in learning contexts: Theoretical advances and methodological implications* (pp. 209–232). London, England: Elsevier.
- Kristof-Brown, A. L., & Guay, R. P. (2011). Person-environment fit. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology* (Vol. 3, pp. 1–50). Washington, DC: APA.
- Li, D., Yi, Q., & Harris, D. (2016). *Evidence for Paper and Online ACT Comparability: Spring 2014 and 2015 Mode Comparability Studies*. ACT Working Paper 2016-02.
- Livingston, S. A., & Lewis, C. (1995). Estimating the consistency and accuracy of classifications based on test scores. *Journal of Educational Measurement, 32*(2), 179–197.
- Mattern, K., Burrus, J., Camara, W., O'Connor, R., Hanson, M. A., Gambrell, J., Casillas, A., & Bobek, B. (2014). *Broadening the Definition of College and Career Readiness: A Holistic Approach* (ACT Research Report No. 2014-5). Iowa City, IA: ACT, Inc.
- Mattern, K., Radunzel, J., & Westrick, P. (2015). *Development of STEM Readiness Benchmarks to Assist Career and Educational Decision Making* (ACT Research Report No. 2015-3). Iowa City, IA: ACT, Inc.
- Nye, C., Su, R., Rounds, J., & Drasgow, F. (2012). Vocational interests and performance: A quantitative summary of over 60 years of research. *Perspectives on Psychological Science, 7*, 384–403.
- Prediger, D. J., & Swaney, K. B. (2004). Work task dimensions underlying the world of work: Research results for diverse occupational databases. *Journal of Career Assessment, 12*(4), 440–459.
- Porter, S., & Umbach, P. (2006). College major choice: An analysis of person-environment fit. *Research in Higher Education, 47*, 429–449.
- Powers, S., Li, D., Suh, H., & Harris, D. J. (2016). *ACT reporting category interpretation guide: Version 1.0* (ACT Working Paper No. 2016-5). Iowa City, IA: ACT, Inc.
- Radunzel, J., Mattern, K., Crouse, J., & Westrick, P. (2015). *Development and validation of a STEM benchmark based on the ACT STEM score* (ACT Technical Brief). Iowa City, IA: ACT, Inc.

REFERENCES

Radunzel, J., Mattern, K., & Westrick, P. (2016). *The role of academic preparation and interest on STEM success*. (ACT Research Report No. 2016-8). Iowa City, IA: ACT, Inc.

Silvia, P. (2006). *Exploring the Psychology of Interest*. New York: Oxford University Press.

Smart, J., Feldman, K., & Ethington, C. (2000). *Academic disciplines: Holland's theory and the study of college students and faculty*. Nashville, TN: Vanderbilt University Press.

Tracey, T., & Robbins, S. (2006). The interest-major congruence and college success relation: A longitudinal study. *Journal of Vocational Behavior*, 69, 64–89.