Introduction

Overview

ACT™ continuously performs research designed to support the content validity of its educational achievement tests. This report presents the results of the 2002–2003 ACT National Curriculum Survey®, ACT's most recent comprehensive review of state educational standards documents, survey of educators, and consultation with content area experts across the curriculum.

The present report devotes one chapter each to English, reading, mathematics, and science, and a fifth chapter to the Standards for Transition® ACT introduced in 1997. This report is the fourth in a series that began with *Content Validity of ACT's Educational Achievement Tests* (1992). That report described ACT's Project Silver research program, a major initiative that underlies ACT's EPAS/Educational Planning and Assessment System®. We reported subsequent research in *Maintaining the Content Validity of ACT's Educational Achievement Tests (1998)* and *Content Validity Evidence in Support of ACT's Educational Achievement Tests: ACT's 1998-1999 National Curriculum Study* (2000).

Together, this series of reports confirms that the EPAS test specifications closely align with school curricula. Though state standards vary in details, they unite in the intention of preparing and encouraging all students to set and reach worthy academic goals, to explore their options for fulfilling work, and to realize their potential for a lifetime of learning. While the approaches vary, their themes are clear: schools should nurture all students' ability to think critically, to communicate cogently and appropriately, to read for information and pleasure, and to achieve literacy in mathematics and science. These are the themes addressed in the present report.

When we go beyond themes to details, we must ask, What should high school students be expected to know, and to be able to do with what they know, across the content areas? What knowledge and abilities do college faculty expect of incoming students? ACT's recent research indicates that the answers to these questions continue to vary among states, schools, and individual educators. National standards documents also express diverse priorities and emphases. ACT therefore seeks the commonalities among the curricula and standards, and we find broad areas of agreement about what skills and knowledge are important. We also poll large numbers of educators to gain the benefit of their sense of instructional priorities. And we confer with content and curriculum experts to help us interpret the results.

Most of the ACT staff members who contributed to this report have teaching experience. They all stay informed about content-validity issues by following the relevant literature, communicating with teachers and test item writers, visiting schools to observe classes, actively participating in professional organizations, and meeting regularly with content-area experts from outside ACT to review in detail all current EPAS test materials under development. Content-validity research is, in short, integral to the work of those who develop the EPAS tests.

ACT's EPAS/Educational Planning and Assessment System

In the 1980s, ACT developed through its Project Silver research program a system that would respond to the educational planning and assessment needs of students, parents, teachers, and administrators. To identify categories of essential information, ACT studied curricula being used in schools nationwide from Grade 7 through the college sophomore level. Completing this comprehensive study included:

- seeking the advice and counsel of college instructors, secondary school teachers, administrators, subject-area experts, and curriculum specialists.
- studying various critiques of education in the United States.
- reviewing state curriculum documents.
- analyzing textbooks widely used in middle school, high school, and college.
- surveying practicing educators across the United States about what is taught in their classrooms.

The study confirmed that there are skills and understandings, developed over time, that are vital to students' success in post-high school careers, whether the students choose to enter the workplace or to pursue a postsecondary education. The results of this study laid the foundation for the design and development of EPAS.

ACT conceives of growth in a student's educational development not as a series of discrete steps but as a continual process. Therefore, ACT's goal in EPAS is to produce an integrated system of assessments each of which is appropriate for a critical transition point in the continuum of a student's educational growth. EXPLORE®, for 8th and 9th graders, focuses on assisting in the transition to high school. PLAN®, for 10th graders, serves as a midpoint assessment of high school progress. And the ACT Assessment®, for 11th and 12th graders, assists in the transition to college.

EXPLORE is designed for use by all 8th and 9th graders. These students need to plan for high school, and EXPLORE helps them see and understand the opportunities open before them. EXPLORE gives educators the means to structure high school planning and career exploration and

provides a baseline to monitor students' progress. Through EXPLORE, a student's strengths and weaknesses can be identified early, and an appropriate learning plan can be developed.

PLAN provides a midpoint review of progress made in high school. Designed for all 10th graders, PLAN provides direction for educational and career planning and allows students to choose courses wisely to prepare to achieve their goals after high school.

The ACT Assessment is designed for 11th and 12th graders who are considering attending a college or university. By using the ACT Assessment, schools not only help those students who are going on to a college or university, but also receive a measure of the outcomes these students have attained by the time they reach their last two years of high school.

Evaluating students' strengths and weaknesses early in Grade 8 and continuing to assess progress through Grade 12, educators gain information necessary to guide students as they prepare for their high school and post-high school goals. As outlined in Table I.1, EPAS provides schools, parents, and students with:

- *a student planning component,* which engages students in a long-term planning process that begins with career exploration and educational planning in Grade 8, moves to career and educational planning in Grade 10, and concludes with students actively preparing for life after high school.
- *an assessment component,* which measures what students can do with what they know in English, mathematics, reading, and science. A fourth EPAS program, WorkKeys®, assesses the skills employers are looking for and helps students develop the workplace skills necessary to obtain the jobs they want after high school.
- *an instructional support component,* which offers teachers support in the classroom. For example, ACT publishes a set of instructional support guides tied to the EPAS programs (one each for Language Arts, Mathematics, and Science) and a series of interpretive guides related to ACT's Standards for Transition.
- *an evaluation component,* which provides information that allows schools to monitor and analyze student performance over time and to assess the effectiveness of school programs.

It is in keeping with ACT cofounder Dr. E. F. Lindquist's philosophy that each EPAS assessment is intended and designed to provide information for multiple purposes, including the evaluation of educational programs, the counseling of students about their course selections, the exploration of and planning for students' career choices, and (for the ACT Assessment) the selection of an institution and an academic area for postsecondary study or an area of employment. Again in keeping with Dr. Lindquist's thinking, although the EPAS test specifications necessarily list the content areas and skills tested, each assessment is designed to assess, not discrete skills in isolation, but the integration of skills and content knowledge. That is, all the assessments are designed to focus not on narrow objectives or course-specific knowledge, but on broad educational achievement and critical thinking developed over time across the curricular areas.

Table I.1
Overview of EXPLORE, PLAN, and the ACT Assessment

Testing program	Target grade	Components	Content areas
EXPLORE	Transition to High School Grades 8–9	• Student Planning • Assessment • Instructional Support • Evaluation	• English • Mathematics • Reading • Science
PLAN	Midpoint High School Review Grade 10	• Student Planning • Assessment • Instructional Support • Evaluation	• English • Mathematics • Reading • Science
ACT Assessment	Transition to High School Grades 11–12	• Student Planning • Assessment • Instructional Support • Evaluation	• English • Mathematics • Reading • Science

Philosophical Basis for ACT's Tests of Educational Development

In conducting its research, ACT observes the guiding principles that Dr. E. F. Lindquist applied in developing ACT's first program, the ACT Assessment Program, in 1959:

- The purposes of testing batteries should not be conceived too narrowly. A testing battery should comprise tests that provide information useful for many constituencies and many purposes: educational planning, career counseling, course planning and placement, instructional planning, program evaluation, and institutional planning at both the secondary and postsecondary levels. The needs to which well-constructed tests respond are hardly narrow: the need to enrich and improve students' educational experiences and the need to motivate student achievement.
- Tests of educational development should measure the student's readiness for further learning, by reproducing as faithfully as possible the complexity of the work students have done and will be expected to do in their future learning, both in and out of school. Such tests should be realistic and practical, and they should demand critical reasoning and thinking.
- Tests of educational development should focus not on innate abilities, but rather on the developed abilities that teachers nourish with their instruction and students cultivate by their own efforts. Such developed abilities, by their complex nature, cannot be measured in isolation. Valid measures of them must elicit acts of judgment that integrate many abilities working in combination. The tests must therefore be based upon the students' learning experiences in the core content areas of high school and college instructional programs, and they must determine what students can *do* with what they have learned, not simply ask for what was learned.
- Tests of educational development, rather than tests of aptitude, are the most useful tests for making course placement and other such decisions based upon instructional programs, precisely because such tests are linked to instruction. It is therefore incumbent on the test developer to design testing batteries that accurately reflect widely accepted educational goals judged important by educators for future learning both in and out of school.

The usefulness of Dr. Lindquist's guideposts continues to impress itself upon us as we survey the educational landscape. During the 2002–2003 ACT National Curriculum Survey, we found many opportunities to reaffirm Dr. Lindquist's propositions that tests of academic development should be versatile, complex, curriculum-based rather than aptitude-based, and consistent with widely accepted educational goals.

Observant of public policies such as the federal No Child Left Behind Act of 2001, and in accord with policy statements such as the Council of Chief State School Officers' recommendation that "schools, previously asked to ensure the development of basic skills, now be required to teach all students a new, broad range of cognitive skills demanded by the changing contexts in which students live," American schools have developed high academic standards and designed flexible curricula and instructional methods to match these standards. In the light of these initiatives, ACT intends to continue to provide information useful to students, parents, educators, and decision makers about individual learners' progress and the progress of the school, district, or state in the subject matter areas most critical to success in high school, college, and work.

Thus, underlying the EPAS tests of educational development is ACT's belief that students' preparation for further learning is best assessed by measuring, as directly as possible, the academic skills that students have acquired and that they will need to perform at the next level of learning. The required academic skills can be most directly assessed by reproducing as faithfully as possible the complexity of the students' schoolwork. Therefore, the tests of educational development are designed to determine how skillfully students solve problems, grasp implied meanings, draw inferences, evaluate ideas, and make judgments in subject-matter areas important to success in intellectual work both inside and outside of school.

Accordingly, the tests of educational development are oriented toward the general content areas of high school and college instructional programs. The test questions require students to integrate the knowledge and skills they possess in major curriculum areas with the information provided by the test. Thus, scores on the tests have a direct and obvious relationship to the students' educational progress in curriculum-related areas and possess a meaning that is readily grasped by students, parents, and educators.

Tests of general educational development are used in the EPAS testing batteries because, when compared to other types of tests, they best satisfy the diverse requirements of tests used to facilitate transitions from one educational level to the next. By contrast, measures of examinee knowledge of specific course content (as opposed to curriculum areas) do not readily provide a common baseline for comparing students' educational development for such purposes as advising, admission, selection, or the awarding of scholarships, because school courses vary so widely. In addition, course-specific tests might not measure students' skills in problem solving and in the integration of knowledge from a variety of courses.

Tests of educational development can also be contrasted with tests of academic aptitude. The stimuli and test questions for aptitude tests are often chosen precisely for their dissimilarity to instructional materials, and each test within a battery of aptitude tests is designed to be homogeneous in psychological structure. With such an approach, these tests might not reflect the complexity of academic work or the interactions among the skills measured. Moreover, because aptitude tests are not directly related to instruction, they may

not be as useful as tests of educational development for informing school counseling, course selection, and placement decisions.

The advantage of tests of educational development over other types of tests for use in school transitions becomes evident in the context of the changing educational system. Because many of the same complex skills that are taught in the schools are being measured, the best preparation for tests of educational development is school coursework. Long-term learning in school, rather than short-term cramming and coaching, becomes the best form of test preparation. Thus, tests of educational development tend to serve as motivators by sending students a clear message that high test scores are not simply a matter of innate ability but reflect a level of achievement that has been earned as a result of hard work and dedication.

Because the EPAS tests stress the complexity of intellectual work and the integration of knowledge from a variety of sources, students may be influenced to acquire the complex skills necessary to deal with these concerns. In this way, the EPAS tests may serve to aid schools in developing in their students the critical reasoning and thinking skills that are important for success in later learning and in life.

The tests of the EPAS testing batteries therefore not only are designed to accurately reflect educational goals that are widely accepted and judged by educators to be important, but are designed with educational considerations, as well as statistical and empirical techniques, given the first rank in importance.

Recognizing the growing importance of reporting detailed assessment results, ACT developed Standards for Transition for the EXPLORE, PLAN, and ACT Assessment programs in 1997. These Standards for Transition, which are presented fully in chapter 5, describe what students who score in various score ranges on the tests of educational development are *likely* to know and to be able to do in each academic area assessed in the EPAS tests: English, mathematics, reading, and science. The Standards for Transition are made widely available, free of charge, through schools and on the ACT website (www.act.org). ACT also offers, through its Standards for Transition Information Services (also described in chapter 5), reporting and instructional support services that can help teachers, curriculum coordinators, and others to interpret their schools' test results and use them appropriately in their teaching plans.

Investigative Process

The foundational evidence for the content validity of ACT's EPAS tests of educational development was obtained through Project Silver in the mid-1980s as described in detail in the 1992 report. This foundation was established with generous help from the many teachers who answered ACT's questionnaires, reviewed draft documents, and came to ACT's national office to meet and discuss testing plans with ACT staff. The foundation is built upon by the many teachers who write ACT EPAS test questions, which are then edited by ACT for administration. And the foundation is, in effect, subjected to scrupulous inspection several times every year—that is, each time ACT's regular test development procedures call for an extensive and stringent review of the tests. In the course of these reviews, conducted by ACT staff and by expert consultants (many of whom are themselves teachers) from outside ACT, each test question is critically examined more than twenty times. Moreover, all EPAS test battery forms are reviewed in detail to ensure that they match current test specifications and thus that their test content is representative of current high school and university curricula.

ACT pursues extensive additional research in the interest of assuring that the EPAS tests continue to be strongly supported by content validity evidence. In 2002–2003, this research took the form of a review of state standards, a curriculum survey, and consultation with content-area and curriculum experts.

In a curriculum review process similar to that described in the 1992 and 1998 reports, ACT (1) synthesized information gathered from state educational standards, (2) surveyed educators as to the skills they deem most important, and (3) consulted with content and curriculum experts about the results from (1) and (2) and to receive the experts' advice about the current status of the curriculum, of instructional practices, and of the appropriateness of the EPAS tests as measures of educational development.

ACT reviewed the latest standards available from the state departments of education (all states but Iowa, which does not publish state standards), most of which were published in 1995 or later. Some were prepublication drafts.

In the spring of 2002, ACT developed 22 surveys (15 for middle/junior high and high school levels, 7 for the postsecondary level) and sent them to 28,926 educators distributed among the four content areas included in the EPAS tests. Because many colleges and universities use ACT Assessment scores to help place students into entry-level courses, the postsecondary surveys were sent to instructors of typical entry-level courses. The surveys sent to teachers and instructors listed both process skills and content skills and asked respondents to rate each skill's level of importance on a scale of 1 through 5. The surveys sent to department chairs listed process skills, with the request that respondents rate each skill's level of importance on a scale of 1 through 5, and included questions about the curriculum in the department chair's school district.

The primary source ACT used in selecting these samples was Market Data Retrieval (MDR), a firm that provides mailing lists, database marketing services, and state-by-state elementary, secondary, and postsecondary school directories to the education market. Among MDR's services is a database of faculty members teaching in primary, secondary, and postsecondary institutions nationwide, indexed by the

courses they teach (e.g., *English Language Arts, Freshman English, Composition*). MDR updates this database yearly through the collection of class schedules and surveys of academic departments.

The ACT survey recipients were sampled from the MDR database, using selection criteria provided by ACT to ensure that a variety of geographic regions and schools were represented. First, ACT requested individuals who were identified by MDR as teaching specific secondary courses or freshman-level postsecondary courses. The courses selected were ones that had some of the largest numbers of entries in the MDR database, indicating that they (or their equivalents) were among the most widely taught courses nationwide. Second, ACT requested that 90% of the middle/junior high and high school recipients come from public schools, with the rest coming from private/parochial schools. This was to safeguard against the recipient pool being biased in favor of small, select institutions. Third, ACT requested that, within each of the four content areas, no more than one individual per school district (for middle/junior high and high school) and no more than one individual per postsecondary institution be included in the sample, so as to ensure that a wide assortment of school districts and institutions were represented in the recipient pool. (The only exception was that the third criterion was waived for lists obtained from the National Council of Teachers of English for use with the Writing survey.) Together, these three criteria were meant to ensure that survey recipients would represent a large number of schools and a variety of geographic locations. Neither the race, ethnicity, gender, nor socioeconomic status of recipients was considered in the selection of these samples. ACT received a total of 6,632 completed surveys, for an overall response rate of almost 23%. The results are analyzed in the content-area chapters of this report. These analyses incorporate the findings of the content experts with whom ACT consulted.

Special Concerns: Fairness, Cultural Diversity, and Effects on Instruction

ACT test developers continue to address three special concerns that bear on test content validity: the fairness of the test passages and test questions, the extent to which the diverse cultures of the United States are represented in the tests, and the influence of the tests on instruction.

A test of educational development must avoid privileging, or discriminating against, any group on any basis other than knowledge and skill in the content domain being measured. For example, if a test question required specialized background knowledge only certain groups would have, then that question would be unfair because it privileged some groups at the expense of others, and it would be technically flawed because it tested something (specialized background knowledge) other than the content construct purportedly being measured. ACT always has been sensitive to issues of fairness in testing. Statistical checks against unfair questions, and independent reviews intended to cull out unfair passages or questions, long have been integral parts of ACT's test development and test evaluation procedures. ACT continually refines its procedures so as to support the content validity of the EPAS tests by guarding against real and perceived sources of unfairness in the tests.

The United States has always contained a vibrant mixture of cultures. Our country's vitality has sometimes been measured by the very rivalries among its constituent cultures, while at other times it has been strengthened by the dignity and heroism with which these cultures have cooperated. In any event, it is a fact of cultural history that persons of many colors, origins, and creeds make up this land. Ignoring or slighting any group or groups misrepresents the cultural landscape. Justice and accuracy require that all cultural groups be represented in educational materials. Accordingly, ACT acquires test materials that reflect our national cultural diversity, and thus is able to ensure multicultural representation in its EPAS testing battery forms. ACT also brings prominent teachers and writers to ACT's national office to advise ACT test development staff on matters of cultural diversity. The content validity of the EPAS tests requires accuracy, and accuracy requires inclusiveness.

The effect that tests may have on instruction is a point of debate and concern for many educators and test developers. It is widely believed that tests inevitably influence instructional practices, and it is often feared that narrow tests may constrict curriculum and teaching. Some critics of standardized tests contend that such tests cannot measure critical reasoning and thinking and that they therefore discourage teachers from tackling challenging subject matter and create an incentive for teachers and students to stick to basic skills. However, ACT is confident that its EPAS tests of educational development do measure critical reasoning and thinking, and that these tests should encourage both teachers and students to reach into the most challenging subjects and instructional modes. ACT's Standards for Transition—descriptions of the skills and knowledge associated with EXPLORE, PLAN, and ACT Assessment scores—are an expression of that confidence. Described fully in chapter 5, the Standards are statements that describe what students who score in specified score ranges typically know and are able to do in English, mathematics, reading, and science. In addition, a series of ACT instructional support booklets indicate, in more detail and for each content area, how the EPAS tests require critical reasoning and thinking skills. These booklets both clarify the connections between critical thinking and the EPAS tests and suggest learning activities conducive to critical thinking. ACT knows that teachers know how to teach. In preparing these booklets we are not offering teaching advice, but sharing some interesting teaching ideas and resources. The booklets demonstrate that the EPAS tests measure critical thinking and that the best way to prepare for EXPLORE, PLAN, and the ACT Assessment is sustained and active learning.

Chapter 1
English and Writing

State Standards

State English language arts standards exhibit wide variability in specificity, from the highly particularized to the broadly generalized, and in emphasis, from those that prescribe basic skills to be mastered, to those that describe large cultural and communications concepts to be explored. This variability in approach and philosophy echoes what ACT has observed in its curriculum reviews during the redevelopment of the ACT Assessment in the 1980s (i.e., Project Silver) and in subsequence ACT National Curriculum Surveys. Similarly, the areas of commonality, which underlie the EPAS English Tests, remain in place. While each set of state standards is expressed in language that the particular state's educators believe best articulate what it is their students should know and/or be able to do, the various states' standards agree in fostering students' knowledge of, and ease in using, standard written English (i.e., "the language of wider communication," NCTE/IRA Standards for the English Language Arts; or, in the nomenclature of the National Assessment of Educational Progress Writing Framework, the "appropriate conventions of written English"). The state standards also share with national standards documents such as the two just mentioned a continued emphasis on students' abilities to organize, revise, and edit writing—that is, on the complex and interrelated sets of skills and knowledge that are examined in the EPAS English Tests.

Educator Surveys

ACT developed four Writing surveys (three for the middle school/junior high and high school levels and one for the postsecondary level) and sent them to 5,570 middle school/junior high and high school teachers, 500 secondary English department chairs, and 5,365 postsecondary faculty teaching entry-level courses. The primary source used in selecting these samples was Market Data Retrieval (MDR), a company specializing in the education market. Survey recipients were sampled from the MDR database using selection criteria provided by ACT to ensure that a variety of geographic regions and schools were represented.

Table 1.1 lists the English and Writing courses that ACT requested MDR use as selection criteria. ACT mailed curriculum surveys to the number of MDR-identified faculty members indicated in the table.

Table 1.1
Writing Courses Used as MDR Sample Selection Criteria

Sample	Courses	Sample Size
Middle School/Junior High	*English Language Arts*	1,200
High School	*English Language Arts, Writing/Composition*	2,400
Postsecondary	Entry-Level Courses	
	Composition	1,000
	Freshman English	750
	Survey of American Literature	300
	Developmental Writing	475
	English as a Second Language	475
Department Chairs	*Middle School/Junior High English Language Arts, High School English Language Arts*	500

A second source of recipient names for the Writing survey was the National Council of Teachers of English (NCTE). NCTE provides external agencies with mailing lists of its members. Member names and addresses may be requested according to types of courses and level of students taught. ACT requested from NCTE a random sample of high school *English Language Arts* and *Composition* teachers and a random sample of postsecondary *College Composition and Communication* instructors. As was the case with the MDR samples, neither race, ethnicity, gender, nor socioeconomic status was considered as a selection criterion. After checking for and removing duplicates between these samples and the MDR samples, ACT mailed an additional 1,970 high school surveys and 2,365 postsecondary surveys to NCTE members. Altogether, 11,435 Writing surveys were mailed across the four sample groups.

The purpose of the surveys was to determine the skills and knowledge deemed important by secondary instructors and postsecondary faculty members teaching entry-level courses. The instructions for completing each survey made this explicit. Middle school/junior high and high school teachers were asked to base their responses on one course they were currently teaching. Postsecondary faculty were asked to base their responses on one entry-level course they were currently teaching. If a postsecondary survey was mailed to a recipient who was not currently teaching a freshman-level course, the instructions asked that the recipient forward the survey to a faculty member who was currently teaching such a course. In order to ensure a good response rate, survey responses were kept confidential; apart from a five-digit identification number linking each survey to a record in either the MDR or NCTE samples, the survey instrument contained no way of identifying the respondent.

A total of 2,360 surveys were returned completed, yielding an overall response rate of 21% for the four surveys. The response rates varied slightly across the four sample groups. Response rates for all four surveys are listed in Table 1.2.

The survey respondents included individuals from all 50 states and the District of Columbia. The representation of the total respondent pool by region was 34.2% from the East (20 states and the District of Columbia), 29.4% from the Midwest (9 states), 12.4% from the Southwest (5 states), and 24.0% from the West (16 states). Analyses of the middle school/junior high, high school, and postsecondary respondent pools determined that they represented a wide variety of geographic locations and institutions. The respondent pool for the department chair survey, however, was found to be biased toward smaller schools. For this reason, survey results for the department chairs are not included in the discussion that follows.

Respondents to all Writing surveys were asked to consider lists of process and content skills. Middle school/junior high and high school respondents were asked to indicate whether they taught each skill in their courses. All respondents were asked to indicate the level of importance of each skill on a scale of 1 to 5, where 1 represented *not important,* 3 represented *moderately important,* and 5 represented *very important*. Middle school/junior high and high school respondents were to rate the importance of each skill to the classes they taught. Postsecondary faculty were to rate each skill as a prerequisite for entry-level coursework.

Included in the Writing surveys was a list of 10 *Writing as Process* skills and 13 *Purposes of Writing*. Respondents were also asked to indicate the relative importance of 37 content skills grouped into six categories: *Writing Strategy, Organization, Style, Sentence Structure, Punctuation,* and *Grammar and Usage.* These six general categories cover the skills measured by the EPAS English Tests. In addition to these content and process skills, respondents were asked to consider 3 *Research Skills* and 10 criteria for the *Evaluation of Writing.*

Table 1.2
Writing Survey Types and Response Rates

Survey type	Number mailed	Number returned	Response rate
Middle School/Junior High	1,200	292	24%
High School	4,370	828	19%
Postsecondary	5,365	1,099	20%
Department Chairs	500	141	28%
Total	11,435	2,360	21%

The Writing surveys also asked respondents a variety of background questions related to the course on which they based their responses. The middle school/junior high and high school respondents were asked to describe the students enrolled in that course as primarily college bound, primarily non-college bound, or a combination of both. They were also asked to name the primary textbook they were using in that course, and to state how many years they had been teaching. Postsecondary respondents were asked to describe that course as either remedial, entry-level, or honors/advanced placement, and to name the primary textbook they were using.

Middle school and junior high school teachers indicated that the skills listed under *Writing as Process* were all more than moderately important, with a median rating of 4.34. Seven of the 10 skills were taught in 89% or more of the courses identified. The respondents ranked the 3 most important process skills as *Editing and proofreading; Prewriting, brainstorming or other techniques of invention;* and *Selecting a topic, formulating a thesis,* in that order. The 13 *Purposes of Writing* were also all rated as more than moderately important, with a median rating of 3.91, although only 6 of those purposes were taught in 76% or more of the courses. See Table 1.3 for a listing of the top-rated writing purposes. The respondents rated *Writing to express one's feelings* as the 4th most important skill, but the high school teachers rated it 10th on their list and the college instructors rated it 8th on theirs.

The items in the next six sections, which represent the content of the EPAS English Tests, all were rated highly—between 3.68 and 4.74, except for *Using a colon to introduce an example or an elaboration,* which was given a mean rating of 1.81. That rating confirms our sense that this skill is not appropriate to test on the EXPLORE English Test. All but 5 of these 37 skills were taught in 71% or more of the courses indicated. The 7 skills listed under *Grammar and Usage* were taught, on average, in 79% of the courses, the lowest percentage of all six categories. See Table 1.4 for the median ratings and percentages taught for these six main groups of skills.

These teachers indicated that the three most important criteria used in the evaluation of student writing were *Using a clear beginning, middle, and ending; Writing unified and coherent text;* and *Using correct grammar, usage, and mechanics,* in that order. See Table 1.5 for a listing of the top-rated criteria.

Of the 78 skills listed, the middle school and junior high school teachers rated the following as the 3 most important skills in their courses: *Punctuating end of sentence, Avoiding sentence fragments,* and *Editing and proofreading,* in that order. See Table 1.9 for the full response data.

High school teachers indicated that the skills listed under *Writing as Process* were all more than moderately important, with a median rating of 4.20. All the skills were taught in 81% or more of the courses identified. High school teachers ranked the 3 most important process skills as *Selecting a topic, Formulating a thesis; Editing and proofreading;* and *Revising focusing on content rather than mechanics,* in that order. The 13 *Purposes of Writing* were also all rated as at least moderately important, with a median rating of 4.23, although only 8 of those purposes were taught in 76% or more of the courses. See Table 1.3 for a listing of the top-rated writing purposes.

The items in the next six sections, which represent the content of the EPAS English Tests, were all rated highly—between 3.99 and 4.69. All but 4 of these 35 skills were taught in 74% or more of the courses. The 7 skills listed under *Grammar and Usage* were taught, on average, in 69% of the courses, the lowest percentage of all six categories. See Table 1.4 for the median ratings and percentages taught for these six groups of skills.

These teachers indicated that the three most important criteria used in the evaluation of student writing were *Developing ideas using relevant examples and details; Using a clear beginning, middle, and ending;* and *Writing unified and coherent text,* in that order. See Table 1.5 for a listing of the top-rated criteria.

Of the 76 skills listed, the high school teachers rated the following as the 4 most important skills in their courses: *Developing logical arguments and supporting them with valid evidence; Making decisions about introductions, conclusions, or transitional devices; Selecting a topic, formulating a thesis;* and *Editing and proofreading,* in that order. See Table 1.9 for the full response data.

College faculty indicated that the skills listed under *Writing as Process* were all more than moderately important as prerequisites to their courses, with the entry-level-course instructors giving them a median rating of 3.64 and the ESL/Developmental instructors giving them a median rating of 3.77. As the high school teachers did, the college instructors ranked the 3 most important process skills as *Selecting a topic, formulating a thesis; Editing and proofreading;* and *Revising focusing on content rather than mechanics.* The college instructors rated only 7 of the 13 *Purposes of Writing* as at least moderately important as prerequisites to their courses. The entry-level-course instructors gave the group a median rating of 3.38, and the ESL/Developmental instructors gave them a median rating of 3.44. See Table 1.3 for a listing of the top-rated writing purposes. The college instructors rated *Evaluating source materials critically* as the 5th most important skill, but the high school teachers rated it 7th on their list and the middle and junior high school teachers rated it 11th on theirs.

The items in the next six sections, which represent the content of the EPAS English Tests, were all rated highly—between 3.46 and 4.41 by the entry-level-course instructors and between 3.67 and 4.43 by the ESL/Developmental instructors. See Table 1.4 for the median ratings for these six groups of skills.

The entry-level-course instructors indicated that the three most important criteria used in the evaluation of student writing were *Developing ideas using relevant examples and details; Writing unified and coherent text;* and *Developing ideas using appropriate organizational strategy,* in that order. The ESL/Developmental instructors came up with the same group but switched the order of the top two criteria. See Table 1.5 for a listing of the top-rated criteria.

Of the 78 skills listed, the entry-level-course instructors rated the following as the most important prerequisite skill for their courses: *Using word processing software programs to write, synthesize, analyze, manipulate, and present information.* The ESL/Developmental instructors rated that skill as the second most important one for their courses, after *Punctuating end of sentence.* See Table 1.9 for the full response data.

Table 1.3
Mean Ratings (and Ranks) of the Top Purposes of Writing, by Respondent Group

Criteria	Middle school & junior high school language arts teachers	High school language arts teachers	College entry-level-course instructors	College ESL/ developmental instructors
Developing logical arguments & supporting them with valid evidence	4.41 (3)	4.69 (1)	4.06 (1)	4.23 (1)
Writing an argumentative or persuasive essay	4.49 (2)	4.53 (2)	3.78 (4)	3.97 (3)
Writing expository prose	4.55 (1)	4.51 (3)	3.86 (3)	3.90 (4)
Interpreting literary texts	4.22 (5)	4.46 (4)	2.68 (11)	2.81 (9)
Analyzing an issue or problem	4.14 (6)	4.38 (5)	3.87 (2)	4.07 (2)

Table 1.4
Ranking of Major Writing Skill Categories, by Respondent Group (Mean Rating, Median % Taught at Secondary School Level)

Rank (1 = most important)	Middle school & junior high school language arts teachers		High school language arts teachers		College entry-level-course instructors		College ESL/ developmental instructors	
1	Writing Strategy	(4.60, 92%)	Writing Strategy	(4.58, 96%)	Grammar & Usage	(4.07)	Sentence Structure	(4.15)
2	Organization	(4.55, 92%)	Sentence Structure	(4.47, 90%)	Sentence Structure	(4.05)	Grammar & Usage	(4.13)
3	Punctuation	(4.45, 88%)	Organization	(4.46, 92%)	Writing Strategy	(3.99)	Organization	(4.11)
4	Grammar & Usage	(4.38, 79%)	Style	(4.37, 92%)	Organization	(3.96)	Writing Strategy	(4.01)
5	Sentence Structure	(4.36, 84%)	Punctuation	(4.36, 83%)	Punctuation	(3.85)	Punctuation	(3.95)
6	Style	(4.25, 84%)	Grammar & Usage	(4.26, 69%)	Style	(3.66)	Style	(3.81)

Table 1.5
Mean Ratings (and Ranks) of the Top Criteria for Evaluating Student Writing, by Respondent Group

Criteria	Middle school & junior high school language arts teachers	High school language arts teachers	College entry-level-course instructors	College ESL/ developmental instructors
Developing ideas using relevant examples & details	4.69 (4)	4.78 (1)	4.60 (1)	4.55 (2)
Writing unified & coherent text	4.70 (2)	4.77 (2)	4.56 (2)	4.60 (1)
Using a clear beginning, middle, and ending	4.82 (1)	4.77 (2)	4.26 (4)	4.34 (5)
Developing ideas using appropriate organizational strategy	4.62 (5)	4.65 (4)	4.36 (3)	4.42 (3)
Using correct grammar, usage, & mechanics	4.70 (3)	4.63 (5)	4.21 (6)	4.35 (4)
Writing appropriately for purpose & audience	4.41 (6)	4.46 (6)	4.22 (5)	4.16 (6)

The survey results support the importance of all six major aspects of writing measured in the EPAS English Tests—punctuation, grammar and usage, sentence structure, strategy, organization, and style—at all grade levels. These appraisals echoed those of ACT's 1995 and 1998 surveys. It also supports the importance of the general construct of the test: to measure students' abilities to edit (for standard written English) and revise (on the basis of content and rhetorical effect) given pieces of short writing. ACT believes that its current EPAS English Test specifications achieve a balance, across all six aspects of writing measured, appropriate for the purposes of the tests.

These survey results also support the development of the ACT Writing Test, a new optional component that will provide a direct measure of students' writing. In particular, the responses summarized in Table 1.3 support the appropriateness of a test that will encourage students to develop logical arguments and support them with valid evidence and to analyze issues or problems. The survey responses support the importance of these writing purposes as indicators of readiness for success at the college level. Similarly, the responses summarized in Table 1.5 provide strong evidence of agreement across secondary and postsecondary levels concerning the importance of these writing skills in terms of evaluating student writing, and as features of a scoring rubric.

Panel Discussions

In early December 2002, ACT convened a National Writing Curriculum Advisory Panel in Iowa City. The panel members were selected to ensure a broad representation of secondary and postsecondary institutions and organizations such as the National Council of Teachers of English and the National Writing Project. The panel included some of the foremost experts in writing instruction, writing assessment, and ESL and developmental writing. (See Table 1.6.) ACT staff discussed the curriculum survey results and other research of state standards and assessments with these panelists, who agreed that the EPAS English Tests provide a useful estimate of students' writing skills for the purposes for which the tests are used. At the same time, they agreed with the recommendations of the 1998 panel that a direct measure of writing would provide additional important information about students' readiness for college-level work. They approved of ACT's Standards for Transition, which they feel provide valuable information that can have a beneficial influence on classroom instruction.

Prior to the panel meeting, each panelist wrote a short paper in response to the following request: *Please describe some of the key features of what you would consider an ideal direct writing assessment to be used for the purpose of supporting decisions about college admissions and/or placement into beginning college writing courses.* There were many common themes or threads in those papers, and those themes coincided with some of the key findings that the panel drew from the survey results and ACT's other research. The discussions of these common themes and threads resulted in a draft of descriptors of what students should be able to do to succeed in first-year college writing courses. (See Table 1.8.) The panel also worked to develop a writing prompt format that would be fair to all students, encourage college-level writing, and give students the opportunity to perform to the best of their abilities in the designated 30-minute time period.

ACT took from the panel meeting a consensus that the EPAS English Test construct maintains its relevancy, that there continues to be strong evidence supporting the EPAS English Tests as valid measures of the construct, and that the Writing Test conceptualized by the panel would complement and enhance the information already provided by the English Tests.

Table 1.6
ACT's 2002 National Writing Curriculum Advisory Panelists

Name	Title and affiliation
Mr. Dale Allender	Associate Executive Director, National Council of Teachers of English
Dr. Bonne August	Professor of English, Kingsborough Community College, City University of New York
Dr. Beverly Ann Chin	Professor of English, University of Montana
Ms. Jan Clinard	Office of the Commissioner of Higher Education in Montana
Ms. Mary Carmen Cruz	English Language Arts Teacher, Cholla High Magnet High School, Tucson, Arizona
Dr. Elyse Eidman-Aadahl	Professor of English, University of California at Berkeley
Ms. Bobbi Ciriza Houtchens	English Language Arts Teacher, Arroyo Valley High School, San Bernardino, California
Dr. Brian Huot	Associate Professor of English, University of Louisville, Kentucky
Dr. Barbara Kroll	Professor of English, California State University, Northridge
Dr. Sandra Murphy	Associate Professor of English Education, University of California at Davis
Mr. Christopher Saheed	English Language Arts Teacher, Cambridge Rindge and Latin High School, Cambridge, Massachusetts

English Test Specifications

Table 1.7 summarizes the specifications for the EXPLORE, PLAN, and ACT Assessment English Tests by showing the number (and proportion) of test questions in each test.

Several features of this coordinated set of English testing programs can be seen in this summary of test specifications. First, as the tests assess higher levels along the content continua, the emphasis of the assessment shifts from usage/mechanics skills like punctuation to more complex, global skills related to strategy, organization, and style. Also, as the target grade level of the testing program increases, so do the number of questions, the number of passages, and the length of the passages. These shifts reflect the expected change in level of sophistication of the examinee population.

The multiple-choice test questions derive from a domain of specific language components that educators agree are important to clear communication. The language components are not tested in isolation, but rather within the context of a passage; their listing here is not meant to be a prescription for language arts education, but merely a means of describing the kinds of writing abilities indirectly measured by the tests.

Table 1.7
English Test Specifications

	Testing program		
Content area	**EXPLORE**	**PLAN**	**ACT Assessment**
Punctuation	6 (.15)	7 (.14)	10 (.13)
Grammar & Usage	8 (.20)	9 (.18)	12 (.16)
Sentence Structure	11 (.28)	14 (.28)	18 (.24)
Strategy	5 (.12)	6 (.12)	12 (.16)
Organization	5 (.12)	7 (.14)	11 (.15)
Style	5 (.12)	7 (.14)	12 (.16)
Total	**40**	**50**	**75**
Passages	4	4	5
Passage Length	300 words	300 words	325 words

English Language Continuum Content Descriptions

Punctuation. The items in this category test the examinee's understanding of the conventions of internal and end-of-sentence punctuation, with emphasis on the capabilities of punctuation to remove ambiguity and clarify meaning.

Punctuating breaks in thought
- End of a sentence (period, exclamation point, question mark)
- Between clauses of compound sentences when conjunction is omitted or when clauses contain commas
- Before a conjunctive adverb joining clauses of a compound sentence
- Parenthetical elements (comma, dash, parentheses)

Punctuating relationships and sequences
- Avoiding ambiguity
- Indicating possessives
- Indicating items or simple phrases in a series
- Indicating restrictive/essential or nonrestrictive/nonessential elements (e.g., participial phrases, subordinate clauses, appositives)

Avoiding unnecessary punctuation
- Between subject and predicate
- Between verb and object
- Between adjective and noun (modifier and modified element)
- Between noun and preposition
- Between preposition and object
- Between two coordinate elements or correlatives
- Within series already linked by conjunctions
- Between intensive and antecedent

Grammar and Usage. The items in this category test the examinee's understanding of agreement between subject and verb, between pronoun and antecedent, and between modifiers and the words modified; formation of verb tenses; pronoun case; formation of comparative and superlative adjectives and adverbs; and idiomatic usage.

Assuring grammatical agreement
- Predicate with subjects of varying complexity (including compound subjects, collective nouns, sentences beginning with *there* or *where*)
- Pronoun with antecedent (only when the relationship is clear)
- Adjectives and adverbs with their corresponding nouns and verbs

Forming verbs
- Tenses of regular and irregular verbs
- Compound tenses

Using pronouns
- Using the proper form of the possessives and distinguishing them from adverbs (*there*) and contractions (*it's* and *who's*)
- Using the appropriate case of a pronoun

Forming modifiers
- Forming comparatives and superlatives of adjectives and adverbs
- Using the appropriate comparative or superlative form depending on the context

Observing usage conventions
- Using the idioms of standard written English

Sentence Structure. The items in this category test the examinee's understanding of relationships between and among clauses, management and placement of modifiers, and shifts in construction.

Relating clauses
- Avoiding faulty subordination, coordination, and parallelism
- Avoiding run-on and fused sentences
- Avoiding comma splices
- Avoiding sentence fragments (except those required in dialogue or otherwise defensible as rhetorically appropriate in their context)

Using modifiers
- Constructing sentences so that antecedents are clear and unambiguous (avoiding squinters and danglers)
- Placing modifiers so that they modify the appropriate element

Avoiding unnecessary or inappropriate shifts in construction
- Person or number of pronoun
- Voice of verb
- Tense of verb
- Mood of verb

Strategy. The items in this category test the examinee's understanding of the appropriateness of expression in relation to audience and purpose; the effect of adding, revising, or deleting supporting material (e.g., the strengthening of compositions with appropriate supporting material); and the effective choice of opening, transitional, and closing sentences. These items focus on the processes of writing: the choices made and strategies employed by a writer in the act of composing or revising.

Making decisions about the appropriateness of expression for audience and purpose

Making decisions about adding, revising, or deleting supporting material

Making decisions about cohesion devices: openings, transitions, and closings
- Selecting an effective statement relative to the essay as a whole
- Selecting an effective statement relative to a specific paragraph or paragraphs

Organization. The items in this category test the examinee's understanding of the organization of ideas and the relevance of statements in context (order, coherence, unity).

Establishing logical order
- Choosing the appropriate conjunctive adverb or transitional expression
- Placing sentences in a logical location
- Ordering sentences in a logical sequence (orderly movement within paragraphs)
- Ordering a series of phrases in a logical way
- Beginning a paragraph in the appropriate place
- Ordering paragraphs in a logical sequence

Judging relevancy
- Omitting irrelevant material (or retaining relevant material)

Style. The items in this category test the examinee's understanding of rhetorically effective management of sentence elements, clarity of pronoun references, economy in writing, and precision and appropriateness of words and images.

Managing sentence elements effectively
- Rhetorically effective and logical subordination, coordination, and parallelism
- Avoiding ambiguity of pronoun reference (only when the relationship is problematic)

Editing and revising effectively
- Avoiding clearly excessive or inappropriate wordiness
- Avoiding redundancy

Choosing words to fit meaning and function
- Maintaining the level of style and tone
- Choosing words and images that are specific, precise, and clear in terms of their context and connotation; recognizing and avoiding mixed metaphors and awkward or nonsensical expressions

No single test form is expected to assess the student's understanding of all of these areas. Rather, the content of the test is sampled from the domain described above and is measured in the context of the passages. Also, the tests do not assess memorized rules of grammar. The emphasis is on the application of sound writing practices to the revising and editing of prose that is typical of that encountered in school and in life in general.

Writing Test Specifications

The new ACT Writing Test will be introduced nationally as an optional component to the ACT Assessment in the 2004–05 school year. It will be an achievement test designed to measure students' writing proficiency and to complement the information currently provided by the ACT English Test. Students will have 30 minutes to write on a single writing prompt. The prompt will provide a rhetorical situation—an issue or a problem with two alternative positions or solutions. The examinees will then be asked to develop and support, through their writing, one of those positions or solutions or to propose a third alternative. The features embedded in the 6-point holistic scoring rubric will be based on a set of descriptors of what students should be able to do in order to succeed in first-year college writing courses. (See Table 1.8.)

Table 1.8
ACT Writing Test Descriptors (What Students Should Be Able to Do)

1. Show the ability to make and articulate judgments by
   - taking a position on an issue or problem.
   - demonstrating the ability to grasp the complexity of issues or problems by considering implications or complications.
2. Sustain a position by focusing on the topic throughout the writing.
3. Develop a position by
   - presenting support or evidence using specific details.
   - using logical reasoning that shows the writer's ability to distinguish between assertions and evidence and to make inferences based on support or evidence.
4. Organize and present ideas in a logical way by
   - logically grouping and sequencing ideas.
   - using transitional devices to identify logical connections and tie ideas together.
5. Communicate clearly by using language effectively and by observing the conventions of standard written English.

Table 1.9

Writing Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group

	Middle/junior				High school				College 1			College 2		
Writing skills and classroom techniques	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank	Mean rating	SD	Rank
Writing as process														
Prewriting, brainstorming or other techniques of invention	96	4.59	0.79	2	94	4.33	0.89	4	3.79	1.16	5	3.90	1.16	5
Mapping, clustering, outlining, or other organizational tools	96	4.45	0.84	4	90	4.09	1.03	6	3.48	1.15	6	3.63	1.18	6
Selecting a topic, formulating a thesis	91	4.54	0.79	3	97	4.68	0.65	1	4.21	1.01	1	4.25	1.02	1
Collaborating with peers in reviews of drafts	89	3.99	1.08	8	91	3.89	1.07	10	3.31	1.22	9	3.22	1.26	10
Editing and proofreading	98	4.72	0.61	1	98	4.67	0.64	2	4.08	1.00	2	4.08	1.08	2
Revising focusing on content rather than mechanics	91	4.32	0.86	6	94	4.34	0.89	3	4.04	1.05	3	3.99	1.09	3
Reflecting on and evaluating one's own writing	93	4.37	0.90	5	92	4.31	0.92	5	3.95	1.06	4	3.97	1.08	4
Developing one's own voice as a writer	79	4.08	1.10	7	81	4.06	1.07	7	3.31	1.16	9	3.33	1.21	7
Changing diction or tone of writing depending on audience addressed	72	3.81	1.17	10	86	3.98	1.03	8	3.33	1.15	8	3.30	1.19	8
Changing focus of paper depending on audience addressed	74	3.90	1.09	9	82	3.92	1.08	9	3.35	1.14	7	3.28	1.22	9
Writing as process median rating	91	4.34			91	4.20			3.64			3.77		
Purposes of writing														
Writing to express one's feelings	93	4.40	0.90	4	85	4.03	1.08	10	2.81	1.19	8	2.98	1.29	8
Writing expository prose	91	4.55	0.80	1	93	4.51	0.84	3	3.86	1.06	3	3.90	1.15	4
Writing an argumentative or persuasive essay	85	4.49	0.82	2	90	4.53	0.83	2	3.78	1.17	4	3.97	1.12	3
Writing a process or "how-to" paper	63	3.97	1.17	7	49	3.39	1.35	11	2.69	1.18	10	2.72	1.26	11
Writing a research paper	59	3.90	1.28	9	72	4.25	1.10	6	3.39	1.34	6	3.44	1.34	7
Writing fiction, telling a story	76	3.91	1.15	8	59	3.38	1.27	12	1.97	1.04	13	2.17	1.25	13
Writing a paper explaining a technical process	30	3.34	1.33	13	27	2.98	1.33	13	2.16	1.09	12	2.28	1.16	12
Writing literary or media analysis	55	3.70	1.25	12	86	4.23	1.00	7	2.71	1.28	9	2.80	1.32	10
Developing logical arguments and supporting them with valid evidence	87	4.41	0.88	3	94	4.69	0.70	1	4.06	1.11	1	4.23	1.09	1
Evaluating and critiquing logical proofs and supporting material in their own argumentative papers	43	3.81	1.30	10	65	4.19	1.11	9	3.38	1.28	7	3.63	1.33	6
Evaluating source materials critically	49	3.79	1.22	11	76	4.23	1.04	7	3.65	1.26	5	3.67	1.29	5
Analyzing an issue or problem	69	4.14	0.98	6	81	4.38	0.94	5	3.87	1.09	2	4.07	1.07	2
Interpreting literary texts	80	4.22	1.05	5	91	4.46	0.88	4	2.68	1.32	11	2.81	1.40	9
Purposes of writing median rating	63	3.91			76	4.23			3.38			3.44		

Table 1.9

Writing Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

Writing skills and classroom techniques	Middle/junior				High school				College 1			College 2		
	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank	Mean rating	SD	Rank
Writing strategy														
Making decisions about the appropriateness of expression for audience and purpose	79	4.25	0.98	11	88	4.28	0.93	12	3.69	1.05	9	3.67	1.22	14
Making decisions about adding, revising, or deleting supporting materials	92	4.60	0.69	4	96	4.58	0.69	3	4.00	0.99	3	4.01	1.06	7
Making decisions about introductions, conclusions, or transitional devices	96	4.68	0.67	1	98	4.69	0.61	1	3.99	1.01	4	4.09	1.05	4
Writing strategy median rating	92	4.60			96	4.58			3.99			4.01		
Organization of writing														
Judging the relevancy of material	80	4.27	1.03	10	88	4.46	0.78	6	3.96	0.96	5	4.11	0.97	3
Beginning a paragraph in the appropriate place	92	4.55	0.79	5	87	4.43	0.84	7	3.84	1.07	7	4.08	1.03	5
Choosing the appropriate transition word or phrase	92	4.50	0.81	6	93	4.39	0.79	9	3.65	1.05	11	3.98	0.98	8
Ordering sentences in a logical way	93	4.65	0.71	3	92	4.55	0.74	4	4.18	0.89	2	4.38	0.88	1
Ordering paragraphs in a logical sequence	93	4.67	0.72	2	93	4.62	0.67	2	4.21	0.90	1	4.37	0.87	2
Organization of writing median rating	92	4.55			92	4.46			3.96			4.11		
Style														
Choosing words and images that are specific, precise, and clear in terms of their context	88	4.49	0.84	7	94	4.55	0.73	4	3.92	0.96	6	4.06	0.93	6
Maintaining consistency of style and tone	73	4.14	1.03	13	84	4.27	0.90	13	3.60	1.00	13	3.76	1.01	13
Avoiding ambiguity of pronoun reference	83	4.21	1.01	12	92	4.38	0.85	10	3.79	1.06	8	3.91	1.04	9
Avoiding wordiness	85	4.28	0.93	9	92	4.35	0.85	11	3.63	1.03	12	3.79	1.03	11
Avoiding redundancy	87	4.33	0.88	8	93	4.41	0.82	8	3.68	1.02	10	3.82	1.06	10
Using rhetorically effective subordination, coordination, and parallelism	45	3.68	1.21	14	76	4.07	1.04	14	3.58	1.07	14	3.77	1.05	12
Style median rating	84	4.25			92	4.37			3.66			3.81		
Rhetorical skills mean importance rating		4.38				4.43			3.84			3.99		

Table 1.9

Writing Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle/junior				High school				College 1			College 2		
Writing skills and classroom techniques	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank	Mean rating	SD	Rank
Sentence structure														
Avoiding faulty subordination and coordination of clauses	55	3.86	1.20	21	74	4.12	0.99	18	3.77	1.05	16	4.01	0.93	12
Avoiding run-on and fused sentences	96	4.67	0.66	3	94	4.60	0.74	2	4.28	0.96	2	4.38	0.88	2
Avoiding comma splices	81	4.29	0.92	14	87	4.43	0.85	7	4.13	1.05	6	4.20	1.00	7
Avoiding sentence fragments	98	4.73	0.64	2	94	4.63	0.71	1	4.25	1.02	3	4.35	0.88	3
Avoiding dangling or misplaced modifiers	64	3.98	1.12	20	78	4.22	0.95	17	3.71	1.10	19	3.84	1.08	18
Avoiding inappropriate shifts in tense, voice, mood, number, or person	87	4.43	0.83	9	93	4.50	0.75	4	3.97	1.02	10	4.09	1.01	10
Sentence structure median rating	84	4.36			90	4.47			4.05			4.15		
Punctuation														
Punctuating end of sentence	96	4.74	0.66	1	77	4.57	0.87	3	4.41	0.98	1	4.43	0.99	1
Punctuating between clauses of compound sentences when conjunction is omitted	88	4.50	0.78	7	84	4.43	0.83	7	3.94	1.08	11	4.04	1.06	11
Punctuating before a conjunctive adverb joining clauses of a compound sentence	72	4.25	1.01	16	79	4.31	0.90	14	3.77	1.11	16	3.82	1.10	19
Punctuating parenthetical elements (commas, parentheses)	80	4.23	1.00	17	83	4.29	0.94	15	3.69	1.08	21	3.78	1.08	20
Punctuating to indicate possession	93	4.58	0.75	5	83	4.48	0.84	5	4.12	1.05	7	4.23	1.01	4
Punctuating essential/nonessential elements, subordinate clauses, appositives	84	4.31	0.90	13	83	4.33	0.88	12	3.70	1.08	20	3.85	1.05	17
Punctuating items in a series	93	4.60	0.73	4	82	4.39	0.91	9	3.92	1.09	13	4.01	1.07	12
Avoiding unnecessary punctuation (commas)	87	4.40	0.83	11	84	4.32	0.90	13	3.74	1.09	18	3.89	1.08	16
Using a semicolon to indicate a relationship between closely related independent clauses	86	4.28	0.94	15					3.60	1.16	22	3.74	1.13	22
Using a colon to introduce an example or an elaboration	80	1.81	0.97	23					3.46	1.14	23	3.67	1.17	23
Punctuation median rating*	88	4.45			83	4.36			3.85			3.95		
Grammar and usage														
Assuring grammatical agreement	91	4.57	0.74	6	89	4.48	0.83	5	4.16	0.99	5	4.21	1.01	6
Forming tenses of regular and irregular verbs	79	4.42	0.86	10	69	4.26	0.98	16	4.20	1.02	4	4.23	1.03	4
Forming compound tenses	59	4.03	1.12	19	57	3.99	1.10	21	3.91	1.09	14	3.93	1.08	15
Using the proper form of possessive pronouns	89	4.44	0.84	8	79	4.38	0.90	10	4.10	1.02	8	4.16	1.05	8
Using the appropriate case of a pronoun	87	4.38	0.92	12	79	4.37	0.90	11	4.07	1.04	9	4.13	1.05	9
Forming modifiers	71	4.18	1.00	18	67	4.10	1.03	19	3.82	1.07	15	3.78	1.07	20
Using the idioms of standard written English	65	3.83	1.14	22	69	4.04	1.05	20	3.94	1.05	11	3.99	1.08	14
Grammar and usage median rating	79	4.38			69	4.26			4.07			4.13		
Usage/mechanics mean importance rating		4.35				4.34			3.94			4.03		

* Median ratings do not include the final two skills, which were not asked of all respondent groups.

Table 1.9

Writing Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle/junior				High school				College 1			College 2		
Writing skills and classroom techniques	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank	Mean rating	SD	Rank
Research skills														
Gathering and synthesizing resources	69	4.23	1.05	2	83	4.45	0.91	1	3.48	1.30	2	3.60	1.32	2
Integrating own ideas with others	68	4.24	1.02	1	83	4.41	0.91	2	3.68	1.27	1	3.77	1.25	1
Formulating open-ended research questions	45	3.77	1.24	3	62	4.05	1.17	3	3.22	1.29	3	3.25	1.30	3
Research skills median rating	68	4.23			83	4.41			3.48			3.60		

	Middle/junior				High school				College 1			College 2		
Evaluation of writing	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank	Mean rating	SD	Rank
Criterion														
Writing appropriately for purpose and audience		4.41	0.84	6		4.46	0.73	6	4.22	0.88	5	4.16	0.93	6
Writing unified and coherent text		4.70	0.66	2		4.77	0.48	2	4.56	0.72	2	4.60	0.73	1
Developing ideas using appropriate organizational strategy		4.62	0.67	5		4.65	0.60	4	4.36	0.82	3	4.42	0.83	3
Developing ideas using relevant examples and details		4.69	0.62	4		4.78	0.47	1	4.60	0.70	1	4.55	0.75	2
Using a clear beginning, middle, and ending		4.82	0.57	1		4.77	0.52	2	4.26	0.93	4	4.34	0.93	5
Using voice		4.05	1.02	9		4.05	0.91	10	3.51	1.04	10	3.67	1.02	10
Using precise word choice		4.31	0.83	8		4.33	0.80	8	3.83	0.91	7	3.95	0.95	7
Using appropriate word tone		3.91	1.03	10		4.12	0.86	9	3.72	0.91	8	3.72	0.94	9
Using sentence variety		4.37	0.81	7		4.37	0.76	7	3.71	0.99	9	3.83	1.01	8
Using correct grammar, usage, and mechanics		4.70	0.60	3		4.63	0.63	5	4.21	0.91	6	4.35	0.86	4
Evaluation of writing median rating		4.52				4.55			4.22			4.25		

Chapter 3
Mathematics

State Standards

All state standards documents include a common core of standards within mathematics influenced by the National Council of Teachers of Mathematics' Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) and Principles and Standards for School Mathematics (NCTM, 2000). While the state standards differ in emphasis and manner of organization, they typically include mathematical reasoning, problem solving, and integration of mathematics topics. The skills and knowledge measured on ACT's EPAS Mathematics Tests align well with the commonalties of skills and knowledge covered within the state standards documents and also with the National Assessment of Educational Progress Mathematics Framework. In other words, the design of the Mathematics Tests, which was based on ACT's Project Silver research project of the 1980s and has been regularly reviewed and refined in light of subsequent ACT National Curriculum Surveys, continues to accurately reflect school curricula.

Educator Surveys

ACT developed four Mathematics surveys and sent them to a total of 5,296 mathematics teachers (middle school/junior high, high school, and college) and department chairs (middle school/junior high and high school). The primary source for these samples was Market Data Retrieval (MDR), a company specializing in the education market. Survey recipients were sampled from the MDR database using selection criteria provided by ACT to ensure that a variety of geographic regions and schools were represented. Further criteria were based on whether the recipient taught one of the eligible courses, or, for the fourth sample, whether the recipient was a mathematics chair in middle school/junior high or high school. Table 3.1 lists the Mathematics courses used as selection criteria. ACT mailed curriculum surveys to the number of teachers and department chairs indicated in the table.

Table 3.1
Mathematics Courses Used as MDR Sample Selection Criteria

Sample	Courses	Sample Size
Middle School/Junior High	*Mathematics, Pre-Algebra, Algebra, Geometry*	1,197
High School	*Mathematics, Pre-Algebra, Algebra, Pre-Calculus, Calculus, Geometry, Statistics, Trigonometry*	2,400
Postsecondary	*Finite Math, Introduction to College Math, Discrete Math, Introduction to Probability, Introduction to Statistics, Probability and Statistics*	400
	Algebra, College Algebra, Precalculus, College Geometry, Geometry	400
	Calculus and Analytic Geometry, Calculus and Functional Analysis, Calculus I, II, and III	400
Department Chairs	*Middle School/Junior High Mathematics, High School Mathematics*	499

Table 3.2
Mathematics Survey Types and Response Rates

Survey type	Number mailed	Number returned	Response rate
Middle School/Junior High	1,197	232	19%
High School	2,400	472	20%
Postsecondary	1,200	324	27%
Department Chairs	499	146	29%
Total	5,296	1,174	22%

A total of 1,174 surveys were returned completed, yielding an overall response rate of 22% for the four surveys. The response rates varied slightly across the four sample groups. Response rates for all four surveys are listed in Table 3.2.

The survey respondents included individuals from all 50 states and the District of Columbia. The representation of the total respondent pool by region was 30.7% from the East, 32.5% from the Midwest, 16.2% from the Southwest, and 20.6% from the West. Analyses of the middle school/junior high, high school, and postsecondary respondent pools determined that they represented a wide variety of geographic locations and institutions. The department chair respondent pool, however, was found to be biased toward smaller schools. For this reason, survey results for the department chairs are not included in the discussion that follows.

Respondents to the Mathematics surveys were asked to consider lists of process and content skills. Middle school/junior high and high school respondents were asked to indicate at what grade level each skill was first taught (introduced) to the typical college-bound student in their school districts. All respondents were asked to indicate the level of importance of each skill on a scale of 1 to 5, where 1 represented *not important,* 3 represented *moderately important,* and 5 represented *very important.* Middle school/junior high teachers were asked to rate the importance of each skill as preparation for high school college-prep courses. High school teachers were to rate each skill as preparation for college. Finally, postsecondary faculty were to rate the importance of each skill as a prerequisite for entry-level coursework for one particular course—the course they taught that had the highest percentage of freshmen.

Middle school/junior high respondents were asked to consider a list of 65 content skills that span the core content covered in middle school/junior high math courses. High school and postsecondary respondents were asked to consider a list of 83 content skills that span the range of content covered in high school and college entry-level math courses (a broader range than is covered by the ACT Assessment Mathematics Test). Both lists of skills were identical to the lists of content skills used in the 1998 survey.

All respondents were also asked to consider a list of 20 process skills related to the processing of mathematical information (e.g., *Choosing an appropriate method for calculating, Using estimation to approximate solutions*) that also were listed in the 1998 survey.

The Mathematics surveys also asked respondents a variety of background questions. The middle school/junior high respondents were asked to indicate the grade level of the students they taught and which of the course types they taught (7th-grade *General Math,* 8th-grade *General Math, Pre-Algebra, Algebra,* and/or *Geometry*). High school respondents were also asked to indicate the grade level of their students and which of the course types they taught (*Algebra, Geometry, Advanced Algebra, Trigonometry, Pre-Calculus/Calculus, Probability/Statistics,* and/or *Discrete Math*). Both middle school/junior high and high school respondents were also asked how many years they had been teaching, the title of the primary textbook series they used, and a series of questions about the use of calculators in their classes and the types of calculators students used. Postsecondary mathematics faculty responded about the course they taught that had the highest percentage of freshmen, listing the course type (*Algebra, Geometry, Pre-Calculus, Calculus, Probability/Statistics,* or *Finite/Discrete Math*) and the course level (remedial, entry-level, or accelerated/honors/advanced placement). They were also asked to name the primary textbook they used, whether they permitted or required the use of calculators in the course, and what type of calculator they permitted/required.

The **middle school/junior high teachers** indicated that all 20 of the process skills were at least moderately important as preparation for college-prep coursework in high school, with 15 of the process skills rated 4.0 or higher. Those process skills receiving the lowest ratings tended to be ones involving theorems and proofs and more sophisticated use of

calculators. There were 11 of the process skills introduced before Grade 8 in at least 70% of the school systems represented, and 14 of the process skills introduced before Grade 9 in at least 70% of the school systems. The rank order of the process skills was essentially the same as in 1998.

The middle school/junior high teachers rated each of the 65 content skills as at least moderately important, with 47 of the content skills rated 4.0 or higher. There were 21 of the content skills introduced before Grade 8 in at least 70% of the schools systems represented, and 41 of the content skills introduced before Grade 9 in at least 70% of the school systems. The ranking of the content skills is very close to that in 1998. Only 5 skills changed by at least 10 places in the rankings. The 4 skills becoming more important are *Finding the slope of a line, Finding the median and mode, Solving systems of two linear equations in two variables algebraically,* and *Working with equations of parallel and perpendicular lines.* The content skill *Classifying plane geometric figures* became less important in the rankings by 10 places.

Approximately 40% of respondents require calculators in one of their classes, 55% make calculators optional in one of their classes, and 25% do not permit calculators in one of their classes. These percentages do not add up to 100% because teachers sometimes have different calculator policies for the different classes that they teach. The most common type of calculator recommended/required is a scientific calculator, with significant percentages also for 4-function calculators and graphing calculators. Table 3.8 summarizes calculator-related responses for the middle school/junior high teachers.

The **high school teachers** indicated that all 20 of the process skills were at least moderately important as preparation for college mathematics courses, with 14 of the process skills rated 4.0 or higher. Those process skills receiving the lowest ratings tended to be the ones involving theorems and proofs, manipulatives, and more sophisticated uses of calculators. There were 12 of the process skills introduced before Grade 10 in at least 70% of the school systems represented and 18 of the process skills introduced before Grade 12 in at least 70% of the school systems. The rank order of the process skills was essentially the same as in 1998. A notable exception was *Recalling quickly basic facts, definitions, formulas, and algebraic procedures then using them correctly to solve a problem,* which went from 13th in 1998 to 5th in 2003.

The high school teachers rated each of the 83 content skills as at least moderately important, with 41 of the content skills rated 4.0 or higher. There were 15 of the content skills introduced before Grade 10 in at least 70% of the school systems represented and 66 of the content skills introduced before Grade 12. The ranking of the content skills is very close to that in 1998. Only 8 skills changed by at least 10 places in the rankings. The 6 skills becoming more important are *Solving quadratic equations by factoring; Performing polynomial long division; Using the discriminant; Finding the mean, median, and mode; Determining the line of best-fit by eye for a set of data;* and *Working with correlations.* The 2 skills that became less important by at least 10 places are *Using the midpoint formula* and *Working with sigma notation.*

Approximately 65% of respondents require calculators in one of their classes, 40% make calculators optional in one of their classes, and 5% do not permit calculators in one of their classes. These percentages do not add up to 100% because teachers sometimes have different calculator policies for the different classes that they teach. The most common type of calculator recommended/required is a graphing calculator, with a significant percentage for scientific calculators and less than 10% for basic 4-function calculators. Table 3.8 summarizes calculator-related responses for the high school teachers.

The **college faculty,** each having chosen a specific entry-level course on which to base their responses, indicated that 11 of the 20 process skills were at least moderately important as prerequisite for the course they chose. Those process skills receiving the lowest ratings tended to be the ones involving constructing proofs, using manipulatives and/or pictorial representations, and using the more sophisticated capabilities of calculators. The ranking of the process skills was essentially the same as in 1998. Notable exceptions were *Recalling quickly basic facts, definitions, formulas, and algebraic procedures then using them correctly to solve a problem,* which went from 8th in 1998 to 2nd in 2003, and *Applying theorems to solve a problem,* which went from 17th to 12th.

The college faculty rated 25 of the 83 content skills as at least moderately important, with 8 of the content skills rated 4.0 or higher. The ranking of the content skills is very close to that in 1998. Only 4 skills changed by at least 10 places in the rankings. The 2 becoming more important are *Understanding continuity* and *Determining maxima, minima, and points of inflection for functions.* The 2 skills that became less important by at least 10 places are *Using counting techniques* and *Working with Venn diagrams.*

Approximately 50% of respondents require calculators in the course on which they based their responses, 40% make calculators optional in that course, and 10% do not permit calculators in that course. The most common type of calculator recommended/required is a graphing calculator, with a significant percentage for scientific calculators and less than 10% for basic 4-function calculators. Table 3.8 summarizes calculator-related responses for the college faculty.

Tables 3.3 and 3.4 present the 5 process skills and the 12 content skills, respectively, receiving the highest mean importance ratings by respondent group. A skill is italicized if all 3 groups ranked it high enough to be in the table. See Tables 3.9 and 3.10 for the full response data.

Table 3.3

Mathematics Process Skills Receiving the Highest Mean Importance Ratings, by Respondent Group

Rank (1 = most important)	Middle school/ junior high school teachers	High school teachers	College faculty
1	*Solving problems posed in real-world settings and interpreting the solution*	*Planning and carrying out a strategy for solving multistep problems*	Performing basic operations with a calculator
2	Reading and interpreting graphs, charts, and other data representations	*Solving problems posed in real-world settings and interpreting the solution*	Recalling quickly basic facts, definitions, formulas, and algebraic procedures then using them correctly to solve a problem
3	*Planning and carrying out a strategy for solving multistep problems*	Performing basic operations with a calculator	*Planning and carrying out a strategy for solving multistep problems*
4	Recognizing and using patterns to solve problems	Reading and interpreting graphs, charts, and other data representations	*Solving problems posed in real-world settings and interpreting the solution*
5	Applying mathematical ideas to new contexts	Recalling quickly basic facts, definitions, formulas, and algebraic procedures then using them correctly to solve a problem	Recognizing and using patterns to solve problems

Table 3.4

Mathematics Content Skills Receiving the Highest Mean Importance Ratings, by Respondent Group

Rank (1 = most important)	Middle school/ junior high school teachers	High school teachers	College faculty
1	*Performing addition, subtraction, multiplication, and division on signed rational numbers*	*Performing addition, subtraction, multiplication, and division on signed rational numbers*	*Performing addition, subtraction, multiplication, and division on signed rational numbers*
2	*Working with ratios and proportions*	*Finding the slope of a line*	*Evaluating algebraic expressions by substitution*
3	Working with percent (e.g., simple interest, tax, and markdowns)	*Using the Pythagorean theorem*	*Simplifying algebraic expressions*
4	Locating points in the coordinate plane†	*Solving linear equations* and inequalities *in one variable*	*Solving linear equations* and inequalities *in one variable*
5	*Simplifying algebraic expressions*	*Simplifying algebraic expressions*	Performing operations with integer exponents
6	Converting fractions to decimals and decimals to fractions†	*Evaluating algebraic expressions by substitution*	*Finding the slope of a line*
7	*Evaluating algebraic expressions by substitution*	*Working with ratios and proportions*	*Working with ratios and proportions*
8	Finding the mean*	Working with linear relationships	Working with number properties (e.g., divisibility, even/odd, and positive/negative)
9	*Solving linear equations in one variable**	Graphing linear equations in two variables	Performing addition, subtraction, and multiplication of polynomials
10	Computing the area and perimeter of polygons*	Using the quadratic formula	Computing a particular value of a function
11	*Finding the slope of a line*	Solving systems of two linear equations in two variables algebraically	Working with linear relationships
12	*Using the Pythagorean theorem*	Working with right triangle trigonometry	*Using the Pythagorean theorem*

*The skill is a subset of a skill listed on the high school and college faculty surveys.

†The skill was included on the middle school/junior high survey only.

Curriculum Consultants

ACT asked eight mathematics educators, representing various teaching levels and areas of the country, to respond with a short essay to each of five questions about the Mathematics survey results, the EPAS Mathematics Tests, and the mathematics curriculum. Table 3.5 identifies these eight consultants.

The consultants generally agreed that the survey results accorded with their sense of the curriculum. They further concurred that the results would provide helpful guidance to test development if interpreted with care, that is, with due allowance for the perspective of each of the respondent groups.

The EPAS Mathematics Tests are, in the consultants' opinions, well matched to school curricula and to college-level expectations. For example, the consultants found item sets (which present examinees with a problem situation and 2–4 items about it) and items couched in real-world contexts to be in line with the curriculum and to constitute an appropriate proportion of the tests.

The consultants identified several trends in the mathematics curriculum. One instance is increased emphasis on probability/statistics/data analysis topics. ACT will continue to monitor such changes and weigh the evidence to determine whether changes in the EPAS Mathematics Test specifications might be warranted.

At this time, ACT's analysis of the survey results, together with the consultants' consensus, supports the general approach and the specific test specifications of the EPAS Mathematics Tests.

Table 3.5
Mathematics Curriculum Consultants

Name	Title and affiliation
Ms. Cindy J. Boyd	Mathematics Teacher, Abilene High School, Abilene, Texas
Dr. Stan Chadick	Professor of Mathematics, Northwestern State University, Natchitoches, Louisiana
Dr. Luis Ortiz-Franco	Associate Professor, Department of Computer Science, Mathematics, and Physics, Chapman University, Orange, California
Mr. Dave Robathan	Mathematics Teacher, Shasta High School, Redding, California
Mr. David J. Tschiggfrie	Mathematics Teacher (recently retired), Washington Junior High School, Dubuque, Iowa Adjunct Professor of Mathematics, Northeast Iowa Community College
Dr. Zalman Usiskin	Professor of Education, University of Chicago, Chicago, Illinois Director, University of Chicago School Mathematics Project
Ms. Stacey Weinand	Mathematics and Science Partnership Coordinator, Oklahoma State Regents for Higher Education, Oklahoma City, Oklahoma
Dr. Rose Mary Zbiek	Associate Professor of Mathematics Education, Pennsylvania State University, University Park, Pennsylvania

Mathematics Test Specifications

The content areas for the EXPLORE, PLAN, and ACT Assessment Mathematics Tests are summarized in Table 3.6. Included in this table is the number (and proportion) of questions in each content area. As can be seen from the table, there is a clear progression in the content coverage of the tests from the 8th- to the 10th- to the 12th-grade-level programs.

Several points need to be made about the labeling of the content areas, especially at the 8th-grade level. At Grade 8, consistent with the National Council of Teachers of Mathematics (NCTM) Standards, "Basic Statistical/Probability Concepts" does not refer to the content of a formal statistics course, but to the ability to process data. Similarly, 8th-grade "Pre-Geometry" deals with use of figures and diagrams to solve mathematical problems. At levels higher than Grade 8, content definitions are consistent with standard course titles in high school.

The cognitive levels assessed by the Mathematics Tests are summarized in Table 3.7. The numbers (and proportions) of questions at each cognitive level are reported in this table. Although at first sight the increase in the proportion of "Knowledge and Skills" questions, and the decline in the proportion of "Understanding Concepts/Integrating Conceptual Understanding" questions, with increasing grade level may seem surprising, it must be remembered that at the higher grade levels the content areas are more challenging.

Table 3.6
Mathematics Test Specifications

	Testing program		
Content area	**EXPLORE**	**PLAN**	**ACT Assessment**
Basic Statistical/Probability Concepts	4 (.13)	*	*
Pre-Algebra	10 (.33)	14 (.35)	14 (.23)
Elementary Algebra	9 (.30)	8 (.20)	10 (.17)
Pre-Geometry	7 (.23)		
Plane Geometry		11 (.27)	14 (.23)
Coordinate Geometry		7 (.18)	9 (.15)
Intermediate Algebra			9 (.15)
Trigonometry			4 (.07)
Total	**30**	**40**	**60**

*On PLAN and the ACT Assessment, questions involving statistics/probability are included in the Pre-Algebra category.

Table 3.7
Cognitive Specifications for the Mathematics Tests

	Testing program		
Cognitive level	**EXPLORE**	**PLAN**	**ACT Assessment**
Knowledge and Skills	8 (.267)	14 (.350)	30 (.500)
Direct Application	8 (.267)	12 (.300)	17 (.283)
Understanding Concepts/Integrating Conceptual Understanding	14 (.467)	14 (.350)	13 (.217)
Total	**30**	**40**	**60**

Although a detailed description of the mathematics continuum is provided in the next section, it must be stressed that Mathematics Test forms are produced by sampling from the domains, rather than by testing every specific skill on every form. Students are advised to prepare for these tests by obtaining a thorough grounding in the full content domain rather than by trying to guess the specific content that will appear on a test form. Each form is a unique sample from the broad content domain; no particular topic in the content areas is guaranteed to appear on a given test form.

Mathematics Continuum Content and Cognitive Level Descriptions

Cognitive Levels

Knowledge and skills. Questions at this level require the student to use one or more facts, definitions, formulas, or procedures to solve problems that are presented in purely mathematical terms.

Direct application. Questions at this level require the student to use one or more facts, definitions, formulas, or procedures to solve straightforward problems set in real-world situations.

Understanding concepts. Questions at this level test the student's depth of understanding of major concepts by requiring reasoning from a concept to reach an inference or a conclusion.

Integrating conceptual understanding. Questions at this level test the student's ability to achieve an integrated understanding of two or more major concepts so as to solve nonroutine problems.

Content Areas

Basic Statistical/Probability Concepts. Questions in this content area (which is treated explicitly in EXPLORE, and implicitly as part of the Pre-Algebra content area in PLAN and the ACT Assessment) involve elementary counting and rudimentary probability; data collection, representation, and interpretation; reading and relating graphs, charts, and other representations of data; and other appropriate topics. All of these topics are addressed at a level preceding formal statistics. Questions in this content area cover the following topics:

- Counting and counting techniques
- The concept of probability
- Mean, median, and mode
- Data collection and representation
- Reading and interpreting graphs, charts, and other representations of data

Pre-Algebra. Questions in this content area are based (as appropriate for the grade levels across EXPLORE, PLAN, and the ACT Assessment) on basic operations using whole numbers, decimals, fractions, and integers; place value; square roots and approximations; the concept of exponents; scientific notation; factors; ratio, proportion, and percent; linear equations in one variable; absolute value and ordering numbers by value; elementary counting techniques and simple probability; data collection, representation, and interpretation; and understanding simple descriptive statistics. Questions in pre-algebra cover the following topics:

- Addition, subtraction, multiplication, and division of whole numbers, decimals, fractions, and integers
- Positive integer exponents
- Prime factorization
- Comparison of fractions
- Ratio and proportion
- Conversion of fractions to decimals, and conversion of decimals to fractions
- Absolute value
- Solution of linear equations in one variable (This is an Elementary Algebra topic for EXPLORE.)
- Percent
- Scientific notation
- Square roots and irrational numbers
- Operations with real numbers (field axioms)
- Order properties for real numbers
- Common factors and common multiples

Elementary Algebra. Questions in this content area are based (as appropriate for the grade levels across EXPLORE, PLAN, and the ACT Assessment) on properties of exponents and square roots, evaluation of algebraic expressions through substitution, using variables to express functional relationships, understanding algebraic operations, and the solution of quadratic equations by factoring. Questions in elementary algebra cover the following topics:

- Evaluation of algebraic expressions by substitution
- Simplification of algebraic expressions
- Addition, subtraction, and multiplication of polynomials
- Factorization of polynomials
- Solution of quadratic equations by factoring
- Formula manipulation and field properties of algebraic expressions

Pre-Geometry. Questions in this category (which applies to EXPLORE only) involve the use of scales and measurement systems, plane and solid geometric figures and associated relationships and concepts, the concept of angles and their measures, parallelism, relationships of triangles, properties of a circle, the Pythagorean theorem, and other appropriate topics. All of these topics are addressed at a level preceding formal geometry. Questions in pre-geometry cover the following topics:

- Using measurement systems
- Using rulers and other scales
- Concepts and relationships for plane and solid geometric figures
- Calculation of perimeter, area, and volume with formulas for selected geometric figures
- The concept of angle and angle measure
- Parallelism
- Properties of triangles
- Properties of circles
- Pythagorean theorem

Plane Geometry. Questions in this content area are based (as appropriate for the grade levels across PLAN and the ACT Assessment) on the properties and relations of plane figures, including angles and relations among perpendicular and parallel lines; properties of circles, triangles, rectangles, parallelograms, and trapezoids; transformations; the concept of proof and proof techniques; volume; and applications of geometry to three dimensions. Items in plane geometry cover the following topics:

- Identification of plane geometric figures
- Basic properties of a circle: radius, diameter, and circumference
- Measurement and construction of right, acute, and obtuse angles
- Parallel lines and transversals
- Congruent and similar triangles
- Areas of circles, triangles, rectangles, parallelograms, trapezoids, and, with formulas, other figures
- Pythagorean theorem
- Lines, segments, and rays
- Perpendicular lines
- Properties of triangles
- Ratio of sides in 45°-45°-90° triangles and 30°-60°-90° triangles
- Circumference and arc length

Coordinate Geometry. Questions in this content area are based (as appropriate for the grade levels across PLAN and the ACT Assessment) on graphing and the relations between equations and graphs, including points, lines, polynomials, circles, and other curves; graphing inequalities; slope; parallel and perpendicular lines; distance; midpoints; and conics. Questions in coordinate geometry cover the following topics:

- Graphing on the number line
- Identification and location of points in the coordinate plane
- Determination of graphs of functions and relations in the plane by plotting points
- Graphs of linear equations in two variables
- Slope of a line
- Distance formula for points in the plane

Intermediate Algebra. Questions in this content area (which applies to the ACT Assessment only) are based on an understanding of the quadratic formula, rational and radical expressions, absolute value equations and inequalities, sequences and patterns, systems of equations, quadratic inequalities, functions, modeling, matrices, roots of polynomials, and complex numbers. Questions in intermediate algebra cover the following topics:

- Solution of linear inequalities in one variable
- Operations with integer exponents
- Operations with rational expressions
- Slope-intercept form of a linear equation
- Operations with radical expressions
- Quadratic formula
- Graphs of parabolas, circles, ellipses, and hyperbolas
- Zeros of polynomials
- Rational exponents
- Equations of circles
- Solution of systems of two linear equations in two variables
- Simple absolute value equations and inequalities
- Graphical solutions to systems of equations and/or inequalities
- Equations of parallel and perpendicular lines

Trigonometry. Questions in this content area (which applies to the ACT Assessment only) are based on understanding trigonometric relations in right triangles; values and properties of trigonometric functions; graphing trigonometric functions; modeling using trigonometric functions; use of trigonometric identities; and solving trigonometric equations. Questions in trigonometry cover the following topics:

- Right triangle trigonometry
- Trigonometric functions
- Graphs of trigonometric functions, including amplitude, period, and phase shift
- Trigonometric identities
- Addition formulas for sine and cosine
- Simple trigonometric equations

Table 3.8
Mathematics Curriculum Survey Results: Calculators in the Classroom, by Academic Level

	Middle school/ junior high*	High school*	College
Use of calculators in mathematics courses			
Required	39%	67%	49%
Optional	57%	39%	41%
Not permitted	26%	6%	10%
Type of calculator recommended or required, as a percentage of respondents who indicated calculators are required or optional in one of their classes			
Basic (4-function)	33%	8%	7%
Scientific	61%	52%	29%
Graphing	28%	71%	54%
Statistical	N/A†	N/A†	3%
Symbolic Manipulator	1%	3%	3%

*Percentages for middle school/junior high and high school may not total 100% because respondents were allowed to check all that applied.
†Middle school/junior high respondents were not given this option.

Table 3.9

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Process Skill, by Respondent Group

	Middle school/junior high				High school				College	
Process skill	% Taught before Grade 8	% Taught before Grade 9	Mean importance rating	Rank	% Taught before Grade 10	% Taught before Grade 12	Mean importance rating	Rank	Mean Importance rating	Rank
Performing basic operations with a calculator	83	89	4.33	11	95	98	4.56	3	3.90	1
Recalling quickly basic facts, definitions, formulas, and algebraic procedures then using them correctly to solve a problem	62	87	4.43	10	79	97	4.47	5	3.79	2
Planning and carrying out a strategy for solving multistep problems	81	94	4.63	3	85	96	4.63	1	3.74	3
Solving problems posed in real-world settings and interpreting the solution	86	93	4.67	1	86	96	4.61	2	3.70	4
Recognizing and using patterns to solve problems	84	93	4.58	4	80	95	4.41	8	3.69	5
Choosing an appropriate method for calculating (e.g., mental, paper and pencil, calculator, or estimation)	87	93	4.49	7	76	86	4.42	7	3.58	6
Applying mathematical ideas to new contexts	74	88	4.51	5	73	93	4.42	6	3.56	7
Reading and interpreting graphs, charts, and other data representations	88	94	4.65	2	87	96	4.52	4	3.55	8
Recognizing generalizations of mathematical ideas	73	88	4.48	9	74	92	4.33	10	3.49	9
Recognizing when essential data are missing	81	92	4.51	6	78	88	4.36	9	3.20	10
Using estimation to approximate solutions	89	95	4.48	8	80	90	4.33	11	3.19	11
Applying theorems to solve a problem	12	38	4.02	15	19	97	4.12	14	2.94	12
Solving several problems representing different aspects/ components of a larger problem or scenario	46	75	4.23	12	52	84	4.15	13	2.93	13
Formulating new patterns or structures	57	79	4.10	14	57	85	3.97	15	2.86	14
Using the graphical capabilities of a calculator	10	43	3.80	17	42	88	4.19	12	2.82	15
Recalling theorems and more complex formulas when needed to solve a problem	13	42	3.91	16	18	94	3.92	16	2.81	16
Demonstrating concepts using manipulatives and/or pictorial representations	86	93	4.10	13	80	89	3.85	17	2.75	17
Constructing and/or critiquing proofs, either informal or formal	4	11	3.44	20	10	95	3.51	19	1.82	18
Using the symbolic manipulation capabilities of a calculator	10	29	3.47	19	17	51	3.28	20	1.79	19
Using the statistical capabilities of a calculator	15	39	3.71	18	20	66	3.66	18	1.70	20
Process skills median rating			4.38				4.33		3.20	

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group

	Middle school/junior high					
Content skill	% Taught before Grade 8	% Taught before Grade 9	% Not taught at all	Mean importance rating	SD	Rank
Performing addition, subtraction, multiplication, and division on signed rational numbers	81	92	0	4.74	0.69	1
Working with scientific notation	75	91	0	3.58	1.15	63
Converting fractions to decimals and decimals to fractions	92	95	0	4.54	0.76	7
Computing common factors and common multiples of numbers	91	95	0	4.28	0.91	24
Computing the absolute value of a number	67	93	0	3.66	1.13	59
Ordering real numbers, including ordering on the number line	84	94	0	4.30	0.97	18
Working with ratios and proportions	82	94	0	4.59	0.66	3
Working with percent (e.g., simple interest, tax, and markdowns)	78	94	0	4.56	0.78	4
Working with number properties (e.g., divisibility, even/odd, and positive/negative)	88	93	0	4.30	0.91	20
Evaluating algebraic expressions by substitution	68	90	0	4.50	0.79	9
Simplifying algebraic expressions	61	89	0	4.55	0.75	5
Solving linear equations in one variable	62	90	0	4.60	0.70	2
Solving linear inequalities in one variable	43	87	0	4.33	0.85	16
Solving absolute value equations and inequalities	20	69	3	3.88	1.03	54
Raising numbers to whole number powers	73	93	1	4.38	0.81	13
Performing operations with integer exponents	33	80	0	4.21	0.94	30
Working with rational exponents	21	58	10	3.86	1.08	55
Simplifying radicals	15	53	4	3.95	1.05	50
Performing addition, subtraction, and multiplication of polynomials	12	55	2	4.27	0.87	26
Solving quadratic equations by factoring	4	40	5	4.18	0.99	31
Using the quadratic formula	2	35	8	4.11	1.02	39
Using the discriminant	1	19	30	3.51	1.22	64
Working with graphs of quadratic equations and functions	5	34	10	4.00	1.04	47
Approximating roots of polynomial and rational equations from graphs	2	24	26	3.68	1.13	58
Determining roots of polynomial and rational equations algebraically	1	27	16	3.90	1.08	52
Computing a particular value of a function	20	60	8	4.14	0.96	37
Recognizing relationships between a function or an equation and its graph	12	58	6	4.14	0.98	35
Performing matrix addition and multiplication	8	31	28	3.34	1.23	65
Solving systems of two linear equations in two variables algebraically	4	46	4	4.23	0.96	28

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group *(continued)*

	Middle school/junior high					
Content skill	% Taught before Grade 8	% Taught before Grade 9	% Not taught at all	Mean importance rating	SD	Rank
Solving systems of equations and inequalities graphically	5	49	4	4.13	1.00	38
Working with series and sequences (e.g., arithmetic and geometric)	59	77	10	4.04	1.00	45
Graphing on the number line	81	92	0	4.28	0.93	25
Graphing solutions to inequalities on the number line	53	92	0	4.08	0.96	42
Locating points in the coordinate plane	85	93	0	4.55	0.74	6
Working with transformations graphically	51	74	12	3.70	1.15	57
Working with transformations algebraically	12	44	22	3.59	1.22	62
Graphing linear equations in two variables	15	64	3	4.31	0.88	17
Finding the slope of a line	18	75	0	4.41	0.80	11
Working with equations of parallel and perpendicular lines	8	55	3	4.17	0.93	34
Working with linear relationships	15	66	3	4.30	0.85	19
Using the midpoint formula	5	41	9	3.89	1.05	53
Using the distance formula	20	55	7	4.10	1.02	40
Using the Pythagorean theorem	39	83	1	4.40	0.87	12
Working with right, acute, and obtuse angles and their properties	73	88	2	4.29	0.88	21
Computing an unknown angle measure in polygons	48	82	5	4.05	0.95	44
Working with lines, segments, and rays and their properties	72	87	3	4.14	0.91	36
Working with parallel lines, transversals, and angle measures	54	83	4	4.18	0.90	32
Classifying plane geometric figures	74	87	2	4.17	0.94	33
Working with properties of special quadrilaterals	53	73	9	3.98	1.00	48
Working with side length relationships in 45°-45°-90° triangles and 30°-60°-90° triangles	19	54	14	4.02	1.01	46
Working with similar triangles	61	86	3	4.09	0.94	41
Working with congruent triangles	59	83	5	4.08	0.93	43
Working with circles (e.g., radius, diameter, arc, and chord)	69	86	4	4.29	0.80	22
Working with inscribed and circumscribed polygons and circles	20	39	25	3.62	1.13	61
Computing the area and circumference of circles	75	91	2	4.37	0.86	14
Computing the area and perimeter of polygons	82	93	2	4.45	0.82	10
Computing volume of prisms and cylinders	59	89	5	4.22	0.91	29
Working with right triangle trigonometry	11	41	23	3.96	1.06	49

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group *(continued)*

	Middle school/junior high					
Content skill	% Taught before Grade 8	% Taught before Grade 9	% Not taught at all	Mean importance rating	SD	Rank
Representing data (e.g., circle graphs, scatterplots, and frequency distributions)	71	92	1	4.29	0.92	23
Finding the mean	87	93	0	4.50	0.79	8
Finding the median and mode	86	94	0	4.37	0.85	15
Computing the probability of a simple event	75	90	2	4.23	0.91	27
Using counting techniques	71	84	8	3.95	1.04	51
Working with Venn diagrams	66	84	10	3.74	1.09	56
Working with mutually exclusive, dependent, and independent events	35	71	11	3.64	1.09	60
Content skills median rating				4.17		

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group *(continued)*

	High school						College		
Content skill	% Taught before Grade 10	% Taught before Grade 12	% Not taught at all	Mean importance rating	SD	Rank	Mean importance rating	SD	Rank
Performing addition, subtraction, multiplication, and division on signed rational numbers	97	99	1	4.77	0.59	1	4.71	0.72	1
Working with ratios and proportions	95	99	0	4.59	0.71	7	4.09	1.10	7
Working with percent (e.g., simple interest, tax, and markdowns)	95	98	2	4.39	0.90	20	3.66	1.27	15
Working with number properties (e.g., divisibility, even/odd, and positive/negative)	96	97	2	4.33	0.93	23	4.05	1.18	8
Evaluating algebraic expressions by substitution	93	99	0	4.61	0.68	6	4.42	0.93	2
Simplifying algebraic expressions	95	99	0	4.68	0.63	5	4.33	1.04	3
Solving linear equations and inequalities in one variable	94	99	0	4.73	0.58	4	4.19	1.15	4
Solving absolute value equations and inequalities	68	98	0	3.99	0.93	42	3.32	1.36	23
Performing operations with integer exponents	82	98	0	4.45	0.78	15	4.14	1.19	5
Working with rational exponents	33	97	0	4.15	0.92	35	3.65	1.43	16
Performing operations on radical expressions/equations	45	97	0	4.20	0.89	30	3.48	1.39	20
Performing addition, subtraction, and multiplication of polynomials	79	98	0	4.46	0.79	14	3.89	1.38	9
Performing polynomial long division	36	92	3	3.37	1.17	71	2.66	1.36	31
Solving quadratic equations by factoring	69	97	0	4.40	0.87	18	3.64	1.46	17
Using the quadratic formula	53	98	0	4.53	0.72	10	3.59	1.45	18
Using the discriminant	21	92	2	3.51	1.09	60	2.49	1.29	39
Solving quadratic inequalities	12	91	2	3.50	1.03	64	2.59	1.40	35
Working with graphs of quadratic equations and functions	30	96	0	4.26	0.84	27	3.34	1.53	22
Approximating roots of polynomial and rational equations from graphs	15	91	2	3.84	1.02	47	2.61	1.46	34
Determining roots of polynomial and rational equations algebraically	17	92	1	4.07	0.93	39	2.79	1.45	29
Performing operations with rational expressions	49	96	0	4.09	0.93	38	3.45	1.43	21
Implementing remainder and factor theorems	7	82	4	3.37	1.04	72	2.17	1.22	51
Computing a particular value of a function	57	97	0	4.44	0.80	17	3.81	1.41	10
Recognizing relationships between a function or an equation and its graph	44	96	0	4.39	0.81	19	3.70	1.46	14
Working with functions (e.g., inverses, composition, and range and domain)	27	94	0	4.12	0.87	36	3.27	1.56	24
Working with graphs of rational functions	17	86	2	3.87	0.95	46	2.79	1.50	29
Working with logarithmic and exponential functions	2	85	2	3.92	0.96	45	2.95	1.59	27

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group *(continued)*

	High school						College		
Content skill	% Taught before Grade 10	% Taught before Grade 12	% Not taught at all	Mean importance rating	SD	Rank	Mean importance rating	SD	Rank
Working with logic statements (e.g., converse, contrapositive, and if-then)	11	90	5	3.36	1.04	73	2.03	1.19	57
Performing matrix addition and multiplication	18	85	5	3.36	1.05	74	1.55	1.04	79
Finding determinants	7	84	5	3.29	1.02	79	1.54	0.99	80
Solving systems of two linear equations in two variables algebraically	69	98	0	4.48	0.74	11	2.99	1.45	26
Solving systems of equations and inequalities graphically	57	98	1	4.10	0.89	37	2.58	1.38	36
Working with series and sequences (e.g., arithmetic and geometric)	15	80	6	3.46	1.01	65	1.86	1.24	61
Working with sequences that are defined recursively	4	65	16	3.11	1.11	80	1.68	1.14	72
Computing the sum of an infinite geometric series	2	59	10	3.09	1.06	81	1.64	1.16	73
Working with sigma notation	1	55	10	3.31	1.06	77	2.11	1.41	54
Working with sets and set notation	44	76	13	3.42	1.15	68	2.48	1.31	40
Working with equations of parabolas, circles, ellipses, and hyperbolas	2	85	2	3.72	0.94	51	2.47	1.40	41
Graphing parabolas, circles, ellipses, and hyperbolas	2	84	2	3.68	0.98	53	2.45	1.39	42
Determining a locus of points	2	68	18	3.06	1.17	82	1.77	1.16	66
Working with vectors in a plane	3	53	14	3.32	1.11	76	1.46	0.91	83
Working with parametric equations	2	35	23	3.01	1.16	83	1.53	1.03	81
Working with transformations graphically	16	81	5	3.54	1.05	58	2.04	1.31	56
Working with transformations algebraically	12	75	8	3.50	1.10	63	2.06	1.31	55
Working with discrete and continuous graphs	9	55	12	3.41	1.06	69	2.32	1.37	47
Graphing linear equations in two variables	80	98	0	4.55	0.73	9	3.71	1.43	12
Finding the slope of a line	91	99	0	4.74	0.58	2	4.13	1.25	6
Working with equations of parallel and perpendicular lines	79	98	0	4.45	0.78	16	3.51	1.43	19
Working with linear relationships	82	99	0	4.57	0.68	8	3.80	1.32	11
Using the midpoint formula	55	98	0	4.17	0.93	34	2.83	1.39	28
Using the distance formula	50	97	0	4.35	0.85	22	3.22	1.47	25
Using the Pythagorean theorem	70	98	0	4.74	0.55	3	3.71	1.42	12
Applying properties of right, acute, and obtuse angles	32	99	0	4.32	0.81	25	2.63	1.44	33
Applying properties of lines, segments, and rays	30	99	0	4.20	0.87	31	2.34	1.37	44
Working with parallel lines, transversals, and angle measures	24	99	0	4.23	0.85	29	2.26	1.35	48
Working with properties of special quadrilaterals	19	99	0	4.02	0.89	40	1.83	1.12	62

Table 3.10

Mathematics Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Skill, by Respondent Group *(continued)*

	High school						College		
Content skill	% Taught before Grade 10	% Taught before Grade 12	% Not taught at all	Mean importance rating	SD	Rank	Mean importance rating	SD	Rank
Working with side length relationships in 45°-45°-90° triangles and 30°-60°-90° triangles	14	97	0	4.31	0.83	26	2.41	1.47	43
Working with congruent and similar triangles	24	99	0	4.26	0.83	28	2.33	1.33	45
Working with circles (e.g., radius, diameter, arc, and chord)	27	98	1	4.20	0.88	32	2.58	1.41	36
Working with inscribed and circumscribed polygons and circles	13	97	2	3.60	1.02	56	1.64	0.98	73
Computing the area and perimeter of polygons and circles	48	98	0	4.47	0.74	13	2.65	1.38	32
Computing volume (e.g., prisms, pyramids, and cylinders)	41	98	1	4.33	0.83	24	2.33	1.36	45
Working with right triangle trigonometry	16	94	0	4.47	0.75	12	2.57	1.64	38
Using trigonometric identities	3	70	1	3.84	1.02	48	2.26	1.55	48
Solving trigonometric equations	3	67	2	3.96	0.97	43	2.14	1.45	52
Using the law of sines and law of cosines	2	73	2	3.96	0.97	44	1.94	1.34	59
Working with graphs of trigonometric functions, including amplitude, period, and phase shift	0	61	2	3.81	0.99	49	2.20	1.56	50
Representing data (e.g., circle graphs, scatterplots, and frequency distributions)	59	88	4	4.18	0.99	33	2.12	1.37	53
Determining a line of best-fit by eye for a set of data	51	86	7	3.75	1.15	50	1.81	1.20	64
Working with correlation	28	72	15	3.52	1.19	59	1.59	1.07	76
Finding the mean, median, and mode	86	96	1	4.38	0.88	21	1.83	1.29	62
Finding the variance and standard deviation of data	10	57	21	3.42	1.18	67	1.56	1.11	78
Working with the normal distribution	8	52	25	3.36	1.18	75	1.49	1.05	82
Computing the probability of a simple event	65	90	4	4.01	1.03	41	1.70	1.26	69
Using counting techniques	51	81	10	3.69	1.15	52	1.70	1.21	69
Working with Venn diagrams	53	82	14	3.31	1.16	78	1.73	1.16	68
Working with mutually exclusive, dependent, and independent events	26	73	9	3.38	1.07	70	1.57	1.13	77
Working with combinations, permutations, and the binomial theorem	8	68	8	3.44	1.04	66	1.60	1.11	75
Finding derivatives	1	15	15	3.64	1.23	54	1.75	1.41	67
Finding definite integrals	0	12	20	3.55	1.27	57	1.70	1.37	69
Determining maxima, minima, and points of inflection for functions	1	33	9	3.60	1.13	55	1.90	1.42	60
Understanding continuity	0	29	11	3.51	1.13	61	2.00	1.43	58
Finding the limit of an expression	0	20	10	3.51	1.15	62	1.81	1.38	64
Content skills median rating				3.99			2.45		

Chapter 2
Reading

State Standards

The majority of state reading standards across the nation emphasize specific reading skills. The skills associated with word meanings (vocabulary) and skills connected to reading literary text are addressed explicitly. However, very few state standards directly address the skills connected to reading informational text. The specifications for the EPAS Reading Tests stipulate that questions about context-dependent vocabulary as well as both literary and informational passages are to be used in the assessments.

While state standards differ in specificity and organization, most integrate the language arts—reading, writing, listening, speaking, and viewing. State standards tend to agree on the same general literacy goals that ACT identified during the redevelopment of the ACT Assessment through Project Silver in the 1980s and that continue to be verified by subsequent ACT National Curriculum Surveys. The following reading abilities maintain a place in reading standards across the United States.

- Use referring and reasoning skills to determine main ideas
- Locate and interpret significant details
- Understand sequences of events
- Make comparisons
- Comprehend cause-effect relationships
- Determine the meaning of context-dependent words, phrases, and statements
- Draw generalizations
- Analyze the author's or narrator's voice and method

All of these skills are measured by the EPAS Reading Tests across reading passages selected from prose fiction, the social sciences, the humanities, and (in the ACT Assessment) the natural sciences.

The EPAS Reading Tests ask test takers to read a variety of texts that span a range of content areas and that are representative of the cultural diversity of the United States, and to apply many different strategies in the act of comprehending, interpreting, and evaluating those texts. In so doing, the EPAS Reading Tests stand in substantial conformity with state reading standards and also with salient provisions of the NCTE/IRA *Standards for the English Language Arts* and the National Assessment of Educational Progress Reading Framework.

Educator Surveys

ACT developed four Reading surveys (three for the middle school/junior high and high school levels and one for the postsecondary level) and sent them to 3,599 middle school/junior high and high school teachers, 500 secondary English department chairs, and 1,600 postsecondary faculty teaching entry-level courses. The primary source used in selecting these samples was Market Data Retrieval (MDR), a company specializing in the education market. Survey recipients were sampled from the MDR database using selection criteria provided by ACT to ensure that a variety of geographic regions and schools were represented.

Table 2.1 lists the Reading courses that ACT asked MDR to use as selection criteria. Reading surveys were mailed to the number of faculty members and department chairs indicated in the table. In all, 5,699 Reading surveys were mailed.

Table 2.1
Reading Courses Used as MDR Sample Selection Criteria

Sample	Courses	Sample Size
Middle School/Junior High	*English Language Arts, Literature, Reading*	1,200
High School	*English Language Arts, Literature, Reading*	2,399
Postsecondary	*Survey of American Literature*	300
	Introduction to Literature	300
	U.S. History Survey	300
	American Government and Politics	300
	Composition and Rhetoric	400
Department Chairs	*Middle School/Junior High English Language Arts, High School English Language Arts*	500

If a postsecondary Reading survey was mailed to a recipient who was not currently teaching a freshman-level course, the instructions asked that the recipient forward the survey to a faculty member who was currently teaching such a course. Individual survey responses were kept confidential.

A total of 1,192 Reading surveys were returned completed, yielding an overall response rate of 21% for the four surveys. The response rates varied slightly across the four sample groups, as shown in Table 2.2.

The survey respondents included individuals from all 50 states and the District of Columbia. The representation of the total respondent pool by region was 29.7% from the East, 31.5% from the Midwest, 16.6% from the Southwest, and 22.2% from the West. Analyses of the middle school/junior high, high school, and postsecondary respondent pools determined that they represented a wide variety of geographic locations and institutions. The department chair respondent pool, however, was found to be biased toward smaller schools. For this reason, survey results for the department chairs are not included in the discussion that follows.

Respondents to the Reading surveys were asked to consider lists of contents and process skills that are, in part, reflective of the content specifications for ACT's EPAS Reading Tests. All respondents were asked to indicate the level of importance of each content or skill on a scale of 1 to 5, where 1 represented *not important,* 3 represented *moderately important,* and 5 represented *very important.* Middle school/junior high and high school respondents were asked to indicate whether they taught each content or skill in a particular course they named and to rate the importance placed on each skill or content in that course. Postsecondary faculty were asked to rate each content or skill in terms of its importance as a prerequisite to success in a particular course they named.

Survey items relating to contents addressed students' developed ability to read and understand 14 different types of texts. These included the 4 broad categories of texts appearing on the EPAS Reading Tests—prose fiction, humanities-based texts, social sciences-based texts, and (on the ACT Assessment only) natural sciences-based texts—as well as 10 specific types of texts, most of which, such as poetry/drama, technical documents, and editorial cartoons, do not appear on the EPAS Reading Tests. In the latter case, the goal was to help determine whether additional text types should be considered for inclusion on the tests. Respondents were also asked to consider 64 reading skills. These skills ran the gamut from simply referring to text and recalling information to synthesizing and evaluating information presented in text. Many of the skills correspond directly with the content specifications of the Reading Tests while others represent skills either only indirectly assessed by the tests or not presently addressed by them at all. As with the 10 text types, this latter set of skills was included to help determine whether additional reading skills should be incorporated into the tests.

The Reading surveys asked respondents a variety of background questions. The middle school/junior high and high school teachers were asked to name a particular course they were teaching and to describe the students in that course as primarily college bound, primarily non-college bound, or a combination of both. They were also asked to name the primary textbook series (if any) they were using in the course and to state how many years they had been teaching. Postsecondary respondents were asked to name a particular course they were teaching, to describe the course as either entry-level, honors/advanced placement, or other (specifying the level), and to name the primary textbook series (if any) they were using in the course.

The **middle school/junior high teachers** rated three of the four broad content areas included on all or some of the EPAS Reading Tests as at least moderately important—*prose fiction* (4.74), *humanities-based texts* (3.43), and *social sciences-based texts* (3.16)—while giving *natural sciences-based texts* a rating of slightly below moderately

Table 2.2
Reading Survey Types and Response Rates

Survey type	Number mailed	Number returned	Response rate
Middle School/Junior High	1,200	249	21%
High School	2,399	495	21%
Postsecondary	1,600	297	19%
Department Chairs	500	151	30%
Total	5,699	1,192	21%

important (2.74). Yet in terms of the percent of teachers who say they taught a given content in the course they named, only *prose fiction* (96%) and *humanities-based texts* (58%) are consistent with the importance ratings, while the percent taught for *social sciences-based texts* (34%) and *natural sciences-based texts* (15%) is at odds with the relatively high importance ratings teachers gave these content areas. The low percent of teachers indicating that they taught the latter two content areas is unsurprising, however, given that language arts teachers were the ones targeted for the secondary-level surveys.

In terms of specific text types, middle school/junior high teachers gave their highest ratings to *poetry/drama* (4.21, 88%), *news and feature articles* (3.93, 76%), and *"functional" texts* (3.89, 72%). ACT currently uses news and feature articles in its EPAS Reading Tests, while "functional" texts are probably inappropriate for a test of academic reading skill. Poetry and drama, however, are viable parts of academic instruction that, based on the survey, merit consideration for the EPAS Reading Tests. Middle school/junior high teachers' lowest ratings went to *advertisements* (3.35, 55%), *editorial cartoons* (2.98, 39%), and *television shows and movies* (2.93, 42%), none of which are used in the Reading Tests. Noteworthy is the fact that even these teachers' lowest-rated text types are still rated moderately important.

Middle school/junior high teachers gave their highest ratings to the following reading process skills: *Making inferences from the text concerning main idea(s)* (4.81, 98%), *Recognizing and recalling main ideas by summarizing* (4.81, 99%), and *Drawing conclusions from information given* (4.81, 99%). All 3 of these skills are currently measured by the EPAS Reading Tests. In fact, as Table 2.5 and the list of content specifications show, all 10 of this respondent group's highest-rated skills are directly mentioned in or inferable from the Reading Tests' specifications. Middle school/junior high teachers gave their lowest ratings to *Judging a text by assessing the risks and benefits of policies or actions it proposes* (3.09, 27%), *Evaluating information in a text for fallacies* (3.06, 24%), and *Judging a text by using different critical lenses or stances* (2.94, 21%). Of these, only *Evaluating information in a text for fallacies* is currently measured by the Reading Tests. While even the 3 lowest-rated skills received ratings of moderately important, they were infrequently taught by this group of respondents. Generally speaking, *evaluating* and *judging* skills received relatively low ratings from all respondent groups.

High school teachers gave ratings similar to those from middle school/junior high teachers to the four broad content areas: *prose fiction* (4.75, 97%) was rated most highly, followed by *humanities-based texts* (3.84, 75%), *social sciences-based texts* (3.33, 40%), and *natural sciences-based texts* (2.57, 10%). As with the former group of teachers, the high school instructors' ratings of *social sciences-based texts* and *natural sciences-based texts* were moderately to markedly out of line with the percent taught.

High school teachers responding to the list of 10 specific text types gave their highest ratings to *poetry/drama* (4.42, 93%), *texts from earlier time periods* (4.09, 79%), and *research studies* (3.69, 61%). Research summaries and texts from earlier time periods are within current EPAS Reading Test specifications, while poetry and drama, as mentioned earlier, are not. This same group of respondents gave their lowest ratings to *technical documents* (2.95, 23%), *advertisements* (2.87, 34%), and *editorial cartoons* (2.80, 31%). None of these text types are used on the Reading Test. Note that *advertisements* and *editorial cartoons* were among the three lowest-rated text types for both groups of secondary-level teachers.

Reading process skills receiving the highest ratings from high school teachers were *Drawing conclusions from information given* (4.83, 100%), *Making inferences from the text concerning main idea(s)* (4.81, 99%), and *Making inferences from the text concerning details that support the main idea(s)* (4.74, 99%). All three are part of the EPAS Reading Tests' specifications. As was the case with the middle school/junior high teachers, all of the high school teachers' 10 highest-rated skills (see Table 2.5 or 2.6) are directly or indirectly represented in the Reading Tests' specifications. Skills receiving the lowest ratings from high school teachers were *Judging a text by using different critical lenses or stances* (3.47, 41%), *Interpreting information from graphs, charts, and diagrams* (3.40, 41%), and *Comparing reviews of literature, film, and performances with one's own response* (3.39, 54%). High school teachers considered even their lowest-rated skills more than moderately important; the high school teachers also taught these skills with moderate frequency. None of these skills are currently a part of the Reading Tests' specifications, although graphs, charts, and diagrams do appear in ACT's EPAS Science Tests.

College faculty considered *social sciences-based texts* (3.65) to be the broad content area most important for students to be able to demonstrate an understanding of prior to attending the class named by the respondents. Regarding the other content areas, college faculty rated *humanities-based texts* (3.55) next most highly, followed by *prose fiction* (2.82) and *natural sciences-based texts* (2.27). The low rating of *prose fiction* compared to the ratings given by the two groups of secondary-level teachers is likely attributable in large part to sampling differences: the college faculty who completed the survey included a high proportion of composition/rhetoric and social science teachers, while very few literature teachers responded (probably because they were not teaching an entry-level course and either routed to the survey to someone else or failed to complete it).

In terms of specific text types, college faculty gave their highest ratings to *editorials/opinion pieces* (3.71), *news and feature articles* (3.66), and *texts from earlier time periods* (3.13). All three of these are encompassed within the EPAS Reading Tests' specifications. Faculty gave their lowest ratings to *advertisements* (2.52), *poetry/drama* (2.40), and

technical documents (2.18). None of these are presently on the Reading Tests. The discrepancy between secondary teachers' and college instructors' ratings for *poetry/drama* is, again, likely attributable in large measure to the presence of a large number of composition/rhetoric and social science teachers and the near-absence of literature teachers in the college sample. Noteworthy also are the overall lower ratings college faculty gave to the broad content areas and specific text types. The median rating for the college faculty in these combined areas was 2.75, while it was 3.52 for middle school/junior high teachers and 3.50 for high school teachers. This is likely due in part to the fact that college faculty were asked to identify prerequisites while secondary-level teachers were asked to rate contents and text types in terms of their importance in their teaching of a particular class.

College faculty gave their highest ratings to the reading process skills of *Drawing conclusions from information given* (4.66), *Making inferences from the text concerning main idea(s)* (4.65), and *Making inferences from the text concerning details the support the main idea(s)* (4.56). All 3 skills are included in the specifications for the EPAS Reading Tests, and, indeed, as with the other two groups, all 10 of the college faculty's highest-rated skills are part of the current specifications of the Reading Tests. Faculty rated lowest the skills of *Evaluating information in a text for significance or importance* (1.91), *Evaluating information in a text for sufficiency of evidence in support of an argument or claim* (1.90), and *Evaluating information in a text for general soundness of reasoning* (1.88). These ratings are appreciably lower than those given to the lowest-rated skills of either group of secondary-level teachers, and, in fact, the median rating for all 64 skills was lowest for the college faculty (2.80); in contrast, the median rating was 3.96 for middle school/junior high teachers and 4.19 for high school teachers. One possible explanation is that college faculty may not expect incoming students to have many of these skills as prerequisites; instead, these instructors may plan to teach these skills during entry-level courses.

Table 2.3 illustrates the ranking, rating, and (for secondary-level teachers) percent taught for the four broad reading content areas, broken down by respondent group.

Table 2.4 gives the ranking, rating, and (where applicable) percent taught for the 10 specific text types, again broken down by respondent group.

Table 2.3
Ranking (Rating, % Taught) of Broad Reading Content Areas, by Respondent Group

Rank (1 = most important)	Middle school & junior high school teachers		High school teachers		College faculty	
1	Prose Fiction	(4.74, 96%)	Prose Fiction	(4.75, 97%)	Social Sciences-Based Texts	(3.65)
2	Humanities-Based Texts	(3.43, 58%)	Humanities-Based Texts	(3.84, 75%)	Humanities-Based Texts	(3.55)
3	Social Sciences-Based Texts	(3.16, 34%)	Social Sciences-Based Texts	(3.33, 40%)	Prose Fiction	(2.82)
4	Natural Sciences-Based Texts	(2.74, 15%)	Natural Sciences-Based Texts	(2.57, 10%)	Natural Sciences-Based Texts	(2.27)

Table 2.4
Ranking (Rating, % Taught) of Specific Text Types, by Respondent Group

Rank (1 = most important)	Middle school & junior high school teachers		High school teachers		College faculty	
1	Poetry/Drama	(4.21, 88%)	Poetry/Drama	(4.42, 93%)	Editorials/Opinion Pieces	(3.71)
2	News and Feature Articles	(3.93, 76%)	Texts from Earlier Time Periods	(4.09, 79%)	News and Feature Articles	(3.66)
3	"Functional" Texts	(3.89, 72%)	Research Studies	(3.69, 61%)	Texts from Earlier Time Periods	(3.13)
4	Editorials/Opinion Pieces	(3.74, 73%)	Editorials/Opinion Pieces	(3.64, 68%)	Research Studies	(3.12)
5	Texts from Earlier Time Periods	(3.63, 59%)	News and Feature Articles	(3.58, 60%)	Editorial Cartoons	(2.67)
6	Research Studies	(3.60, 53%)	"Functional" Texts	(3.42, 58%)	"Functional" Texts	(2.66)
7	Technical Documents	(3.36, 36%)	Television Shows and Movies	(2.69, 50%)	Television Shows and Movies	(2.56)
8	Advertisements	(3.35, 55%)	Technical Documents	(2.95, 23%)	Advertisements	(2.52)
9	Editorial Cartoons	(2.98, 39%)	Advertisements	(2.87, 34%)	Poetry/Drama	(2.40)
10	Television Shows and Movies	(2.93, 42%)	Editorial Cartoons	(2.80, 31%)	Technical Documents	(2.18)

Tables 2.5 and 2.6 compare the 10 highest-rated reading process skills for the various respondent groups. Note that all three groups shared 4 skills in common (these have been italicized in both tables) and that the middle school/junior high and high school teachers had a total of 7 skills in common. As mentioned above, all of these skills are a direct part of or are embedded within the EPAS Reading Tests' specifications. See Table 2.9 for the full response data.

Table 2.5
Reading Skills Receiving the Highest Mean Importance Ratings by Middle School/Junior High Teachers and by High School Teachers

Rank (1 = most important)	Middle school & junior high school teachers		High school teachers	
1	*Making inferences from the text concerning main idea(s)*	(4.81, 98%)	*Drawing conclusions from information given*	(4.83, 100%)
2	*Recognizing and recalling main ideas by summarizing*	(4.81, 99%)	*Making inferences from the text concerning main idea(s)*	(4.81, 99%)
3	*Drawing conclusions from information given*	(4.81, 99%)	*Making inferences from the text concerning details that support the main idea(s)*	(4.74, 99%)
4	*Making inferences from the text concerning details that support the main idea(s)*	(4.79, 98%)	*Recognizing and recalling main ideas by summarizing*	(4.68, 96%)
5	Determining specific meanings of words and phrases from the context in which they appear	(4.74, 98%)	Determining specific meanings of words and phrases from the context in which they appear	(4.67, 98%)
6	Recognizing and recalling specific details	(4.73, 99%)	Making inferences from the text concerning cause-effect relationships	(4.67, 97%)
7	Predicting outcomes	(4.71, 97%)	Identifying the author's purpose	(4.67, 97%)
8	Recognizing and recalling main ideas by selecting key words in sentences and paragraphs	(4.70, 96%)	Recognizing and recalling comparisons	(4.64, 99%)
9	Making inferences from the text concerning cause-effect relationships	(4.70, 98%)	Recognizing and recalling specific details	(4.64, 99%)
10	Recognizing and recalling main ideas by selecting topic sentences	(4.69, 95%)	Identifying literal and figurative meanings where appropriate	(4.63, 97%)

Overall, the survey results indicate that the aspects of reading that the respondents think are central to classroom work are the same aspects emphasized in the EPAS Reading Tests. Although the design of the 2003 surveys differs from that of their 1998 predecessors, the 2003 results give no evidence of radical changes in the curriculum. In fact, despite the increased length of the 2003 surveys and some wording changes to items remaining from 1998, middle school/junior high respondents rated 6 of the same skills in both 1998 and 2003 among their 10 most highly rated, while the high school teachers had 7 of 10 and the college faculty 9 of 10 skills in common across studies.

Table 2.6
Reading Skills Receiving the Highest Mean Importance Ratings by High School Teachers and by College Faculty

Rank (1 = most important)	High school teachers		College faculty	
1	*Drawing conclusions from information given*	(4.83, 100%)	*Drawing conclusions from information given*	(4.66)
2	*Making inferences from the text concerning main idea(s)*	(4.81, 99%)	*Making inferences from the text concerning main idea(s)*	(4.65)
3	*Making inferences from the text concerning details that support the main idea(s)*	(4.74, 99%)	*Making inferences from the text concerning details that support the main idea(s)*	(4.56)
4	*Recognizing and recalling main ideas by summarizing*	(4.68, 96%)	Distinguishing between fact, opinion, and reasoned judgment	(4.53)
5	Determining specific meanings of words and phrases from the context in which they appear	(4.67, 98%)	Recognizing and recalling cause-effect relationships	(4.49)
6	Making inferences from the text concerning cause-effect relationships	(4.67, 97%)	*Recognizing and recalling main ideas by summarizing*	(4.45)
7	Identifying the author's purpose	(4.67, 97%)	Making inferences from the text concerning cause-effect relationships	(4.44)
8	Recognizing and recalling comparisons	(4.64, 99%)	Recognizing and recalling comparisons	(4.41)
9	Recognizing and recalling specific details	(4.64, 99%)	Identifying the author's purpose	(4.38)
10	Identifying literal and figurative meanings where appropriate	(4.63, 97%)	Recognizing and recalling main ideas by selecting topic sentences	(4.25)

Panel Discussions

In July 2003, ACT held a Reading Curriculum Panel in Iowa City. The panel members were selected to ensure a broad representation of secondary and postsecondary institutions. The panel included some of the foremost experts in the teaching of reading in both English language arts courses and other content areas. Table 2.7 identifies the panelists.

Prior to attending the panel, each participant wrote a brief paper that described his or her perceptions of current and emerging trends in reading curriculum and instruction; interpreted the curriculum survey data; and recommended changes to the current EPAS Reading Tests. ACT staff circulated the set of panelist papers to the entire group prior to the July 11 meeting. At the meeting, ACT staff discussed the three main topics identified above with the panelists, attempting to reach consensus on the key issues relating to the reading curriculum and the tests.

Panelists gave a strong endorsement of the present EPAS Reading Tests and recommended that no skills currently assessed be dropped from the test specifications. The panelists' suggestions for potential enhancements to the Reading Tests were discussed in detail. ACT is devoting further consideration and research effort to the most promising of the ideas offered by the panelists and generated by the panel discussion.

Table 2.7
ACT's 2003 Reading Curriculum Panelists

Name	Title and affiliation
Mr. Bruce Damasio	Social Studies Teacher and Department Chair, Liberty High School, Eldersburg, Maryland
Ms. Barbara Fowler	Reading Specialist and Adjunct Instructor, Longview Community College, Lee's Summit, Missouri
Dr. Donald L. Hatcher	Professor of Philosophy; Co-Director, Freshman Critical Thinking/Composition Program; and Director, Center for Critical Thinking, Baker University, Baldwin, Kansas
Ms. Alicia Hernandez	Professor of English, Rio Hondo College, Whittier, California
Ms. Carol Jago	English Teacher, Santa Monica (California) High School
Ms. Ronda Marshall	Language Arts Teacher, Northwest Junior High School, Iowa City, Iowa
Dr. David O'Brien	Professor of Education, University of Minnesota–Twin Cities
Ms. Marilyne Ross	Reading Specialist, Orange County Public Schools, Orlando, Florida
Ms. Annette Sample	English Teacher, George Washington Carver High School for Engineering and Science, Philadelphia, Pennsylvania
Dr. Cynthia (Hynd) Shanahan	Professor of Education, University of Illinois at Chicago
Dr. Peter Thacker	Literacy Instruction Specialist, Jefferson High School, Portland, Oregon

Reading Test Specifications

The text content areas, number of passages, passage lengths, and number (and proportion) of items for the EXPLORE, PLAN, and ACT Assessment Reading Tests are summarized in Table 2.8.

The detailed description of the test content given on page 30 is presented to give an overview of the domains of test content that are assessed. It is not presented as a guide to instruction or as a specific list of topics that will be covered in any particular test form. When a test form is produced, test items are sampled from these domains.

Table 2.8
Reading Test Specifications

	Testing program		
Content area	**EXPLORE**	**PLAN**	**ACT Assessment**
Prose Fiction	10 (.33)	8 (.32)	10 (.25)
Humanities	10 (.33)	9 (.36)	10 (.25)
Social Sciences	10 (.33)	8 (.32)	10 (.25)
Natural Sciences			10 (.25)
Total	**30**	**25**	**40**
Passages	3	3	4
Passage Length	500 words	500 words	750 words

Reading Continuum Content and Cognitive Level Descriptions

Cognitive Levels

Questions in the Reading Tests are classified in the general categories of Referring and Reasoning.

Referring. The questions in this category ask about material explicitly stated in a passage. These questions are designed to measure literal reading comprehension. A question is classified in the Referring category if the information required to answer it is directly given in the passage text. In such questions, there are usually relationships between the language of the passage and that of the question, and the answer to the question is typically evident in a single sentence, or two adjacent sentences, in the passage. Some Referring questions paraphrase the language of the passage.

Main ideas
- Recognizing the main idea of a passage
- Recognizing the main idea of a paragraph or paragraphs

Significant details
- Recognizing the information in a written passage that answers the questions who, what, where, when, why, and how

Relationships
- Recognizing sequences
- Recognizing cause-effect relationships
- Recognizing comparative relationships (comparisons and contrasts)

Reasoning. The questions in this category ask about meaning implicit in a passage and require cogent reasoning about a passage. These questions are designed to measure "meaning making" by logical inference, analysis, and synthesis. A question is classified in the Reasoning category if it requires inferring or applying a logical process to elicit an answer from the passage, or if it demands that the examinee combine many statements in the passage or interpret entire sections of the text.

Inferences from the text
- Inferring the main idea or purpose of a passage
- Inferring the main idea or purpose of a paragraph or paragraphs
- Showing how details are related to the main idea (e.g., how they support the main idea)
- Inferring sequences
- Inferring cause-effect relationships

Critical understanding of the text
- Drawing conclusions from information given
- Making comparisons and contrasts using stated information
- Making appropriate generalizations
- Recognizing logical fallacies, rhetorical flaws, or limitations in texts
- Recognizing stereotypes
- Understanding point of view
- Distinguishing between fact and opinion

Vocabulary
- Determining specific meanings of words or short phrases within the context of a passage

Content Areas

The content of the Reading Tests ranges widely among topics under the content areas named in Table 2.8. As is true of the other content domains, the stimulus material for the Reading Tests becomes more challenging with the increase in the grade level being assessed; as Table 2.8 shows, at the 8th-/9th- and 10th-grade levels, three content areas are used to assess reading skill (prose fiction, humanities, and social sciences). At the 11th-/12th-grade level, natural sciences text material is added.

Prose fiction. The questions in this area are based on intact short stories or passages from short stories or novels.

Humanities. The questions in this area are based on passages from memoirs, personal essays, and essays on architecture, art, dance, ethics, film, language, literary criticism, music, philosophy, radio, television, or theater. Passages describe or analyze works of art, ideas, or values.

Social sciences. The questions in this area are based on passages in anthropology, archaeology, biography, business, economics, education, geography, history, political science, psychology, or sociology. Passages typically present information gathered by research into written records or survey sampling rather than data gained by scientific experimentation.

Natural sciences. The questions in this area are based on passages in anatomy, astronomy, biology, botany, chemistry, ecology, geology, medicine, meteorology, microbiology, natural history, physiology, physics, technology, or zoology. Passages present a science topic with a lucid explanation of its significance.

Question Ordering

Reading Test questions are arranged according to a protocol that places more general questions ahead of more specific questions and that places questions about portions of the passage in the order in which those portions appear in the passage. ACT adopted this protocol, with the approval of reading consultants from outside ACT and after careful consideration of the measurement issues involved, to provide examinees with as natural and logical a sequence of items as possible.

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group

	Middle school/junior high				High school				College		
Reading content	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Reading and demonstrating understanding of. . .											
prose fiction (e.g., novels, short stories)	96	4.74	0.63	1	97	4.75	0.63	1	2.82	1.41	3
humanities-based texts (e.g., the arts, philosophy, architecture, religion/ethics, literary criticism, personal essays, memoirs)	58	3.43	1.26	2	75	3.84	1.18	2	3.55	1.19	2
social sciences-based texts (e.g., history, political science, economics, psychology, business, geography, archaeology)	34	3.16	1.33	3	40	3.33	1.41	3	3.65	1.24	1
natural sciences-based texts (e.g., biology, chemistry, physics, physical sciences)	15	2.74	1.41	4	10	2.57	1.46	4	2.27	1.20	4
Reading and demonstrating understanding of. . .											
poetry/drama	88	4.21	0.98	1	93	4.42	0.91	1	2.40	1.29	9
"functional" text (e.g., brochures, business letters, maps)	72	3.89	1.14	3	48	3.42	1.40	6	2.66	1.28	6
technical documents (e.g., instructional manuals, contracts)	36	3.36	1.41	7	23	2.95	1.46	8	2.18	1.21	10
news and feature articles	76	3.93	1.08	2	60	3.58	1.27	5	3.66	1.26	2
editorials/opinion pieces	73	3.74	1.15	4	68	3.64	1.16	4	3.71	1.26	1
editorial cartoons	39	2.98	1.34	9	31	2.80	1.31	10	2.67	1.33	5
advertisements	55	3.35	1.24	8	34	2.87	1.38	9	2.52	1.31	8
television shows and movies	42	2.93	1.22	10	50	2.96	1.30	7	2.56	1.23	7
research studies	53	3.60	1.32	6	61	3.69	1.35	3	3.12	1.33	4
texts from earlier time periods (e.g., an 18th century short story, a political speech given during the Civil War)	59	3.63	1.20	5	79	4.09	1.08	2	3.13	1.36	3
Reading content median rating		3.52				3.50			2.75		

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle school/junior high				High school				College		
Reading skill	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Recognizing and recalling main ideas by . . .											
selecting topic sentences	95	4.69	0.65	10	87	4.51	0.86	20	4.25	1.05	10
selecting key words in sentences and paragraphs	96	4.70	0.62	8	88	4.53	0.84	15	4.13	1.06	17
summarizing	99	4.81	0.54	2	96	4.68	0.66	4	4.45	0.85	6
Recognizing and recalling . . .											
specific details	99	4.73	0.54	6	99	4.64	0.66	9	4.14	1.02	16
narrational and chronological sequences	99	4.68	0.63	12	98	4.59	0.66	13	4.16	1.05	15
cause-effect relationships	98	4.69	0.64	11	97	4.63	0.66	11	4.49	0.79	5
comparisons	99	4.66	0.69	14	99	4.64	0.62	8	4.41	0.83	8
Making inferences from the text concerning . . .											
main idea(s)	98	4.81	0.49	1	99	4.81	0.50	2	4.65	0.71	2
details that support the main idea(s)	98	4.79	0.52	4	99	4.74	0.54	3	4.56	0.76	3
narrational and chronological sequences	95	4.65	0.62	15	96	4.61	0.70	12	4.20	1.00	14
cause-effect relationships	98	4.70	0.64	9	97	4.67	0.63	6	4.44	0.83	7
Drawing conclusions from information given	99	4.81	0.47	3	100	4.83	0.44	1	4.66	0.65	1
Predicting outcomes	97	4.71	0.59	7	96	4.53	0.78	16	3.62	1.13	22
Identifying literal and figurative meanings where appropriate	96	4.47	0.83	20	97	4.63	0.61	10	3.84	1.06	21
Determining specific meanings of words or phrases from the context in which they appear	98	4.74	0.55	5	98	4.67	0.63	5	4.23	0.91	13
Distinguishing between fact, opinion, and reasoned judgment	98	4.68	0.63	13	90	4.56	0.79	14	4.53	0.79	4
Relating own experiences to characters and events in a text	97	4.57	0.75	16	97	4.43	0.85	25	3.46	1.20	24
Using information implied in a text to make . . .											
comparisons	95	4.47	0.74	18	98	4.53	0.70	17	4.24	0.89	11
generalizations	93	4.35	0.84	23	95	4.47	0.77	23	4.24	0.88	11

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle school/junior high				High school				College		
Reading skill	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Recognizing and determining the presence of and effect on a text of . . .											
stereotypes	85	4.26	0.94	26	90	4.35	0.88	26	3.90	1.10	19
point of view	96	4.47	0.78	19	95	4.52	0.74	18	4.09	1.02	18
Identifying the author's purpose	96	4.50	0.79	17	97	4.67	0.68	7	4.38	0.90	9
Recognizing and understanding the use of literary devices . . .											
satire	58	3.69	1.24	41	80	4.24	1.03	32	2.94	1.26	30
irony	79	4.05	1.13	32	91	4.47	0.84	22	2.99	1.28	28
metaphor/simile	95	4.42	0.82	21	93	4.46	0.84	24	3.07	1.29	26
foreshadowing	92	4.40	0.89	22	93	4.50	0.79	21	2.71	1.29	35
symbolism	86	4.19	1.05	28	93	4.52	0.77	19	2.93	1.31	31
Recognizing how history/culture influences a text	71	3.88	1.08	33	85	4.26	0.92	31	3.87	1.13	20
Using various strategies to monitor one's own reading	82	4.34	1.01	24	71	4.01	1.04	37	3.57	1.17	23
Comparing reviews of literature, film, and performances with one's own response	48	3.35	1.22	57	54	3.39	1.18	64	2.71	1.22	35
Analyzing interactions between main and subordinate characters and ideas in literary and informational texts (e.g., internal and external conflicts, motivations, relationships, and influences)	86	4.23	0.97	27	89	4.31	0.91	29	2.70	1.27	37
Interpreting information from graphs, charts, and diagrams, such as maps, blueprints, or schematics	56	3.75	1.25	38	41	3.40	1.35	63	2.96	1.43	29

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle school/junior high				High school				College		
Reading skill	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Recognizing in a text the...											
primary mode or organizational structure (narrative, descriptive, expository, argumentative/persuasive)	82	4.26	0.98	25	83	4.15	1.00	33	2.32	1.29	47
types of claims made (e.g., factual claims, value judgments)	62	3.79	1.15	35	66	3.89	1.11	43	1.99	1.16	60
types of evidence used (e.g., experimentation, expert testimony, statistics, case studies, "common sense")	39	3.40	1.19	53	53	3.61	1.23	57	2.09	1.15	57
sources of information used (e.g., where information comes from; whether a source is primary or secondary)	54	3.64	1.16	43	67	3.88	1.20	44	1.98	1.05	61
Analyzing a text to ...											
determine the amount of prior and/or specialized knowledge a reader is expected to have on the topic	45	3.55	1.30	46	54	3.60	1.24	58	2.82	1.17	32
categorize or classify information (e.g., identifying common characteristics)	68	3.78	1.19	37	74	3.86	1.03	46	2.52	1.13	42
identify an author's unstated assumptions	56	3.51	1.29	51	75	3.95	1.05	42	2.24	1.15	50
understand how writing style conveys or shapes meaning(e.g., the use of the passive voice in writing to disguise who is acting or to distance a person from responsibility for an action)	43	3.42	1.30	52	66	3.87	1.14	45	2.55	1.30	40
identify confusing, ambiguous, or vague language	62	3.69	1.18	42	77	3.97	1.10	40	2.33	1.16	46

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle school/junior high				High school				College		
Reading skill	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Evaluating information in a text for...											
specificity (appropriate level of precision is used)	37	3.27	1.26	59	52	3.63	1.26	56	2.36	1.07	44
relevance	60	3.73	1.21	39	76	4.02	1.08	36	2.04	0.99	58
significance or importance	67	3.78	1.20	36	81	4.11	1.06	35	1.91	0.96	62
fairness (opposing arguments are represented fairly)	54	3.53	1.18	49	60	3.72	1.22	53	2.11	1.03	56
appeals (e.g., to logic, emotions, morals, authority, the senses)	53	3.54	1.22	47	68	3.83	1.14	47	2.24	1.10	50
loaded language (e.g., euphemisms, gender-based words)	47	3.37	1.23	55	67	3.80	1.20	50	2.32	1.11	47
persuasive techniques/propaganda (e.g., leading questions, testimonials, sound bites)	58	3.69	1.22	40	66	3.77	1.20	52	2.30	1.15	49
fallacies (e.g., false analogy, begging the question, non sequitur, ad hominem)	24	3.06	1.28	63	47	3.57	1.32	59	2.36	1.19	44
erroneous, biased, or dubious assumptions	35	3.29	1.26	58	53	3.68	1.24	55	2.15	1.08	54
credibility and appropriateness of sources of information	48	3.61	1.29	44	69	3.96	1.18	41	2.02	1.05	59
sufficiency of evidence in support of an argument or claim	49	3.53	1.28	48	69	4.00	1.19	38	1.90	0.98	63
completeness (sufficient breadth and depth is included; no important omissions exist)	33	3.35	1.25	56	58	3.80	1.26	51	2.14	1.07	55
internal consistency	32	3.27	1.32	60	54	3.70	1.26	54	2.17	1.13	53
general soundness of reasoning	47	3.52	1.29	50	67	3.98	1.20	39	1.88	0.94	64

Table 2.9

Reading Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content/Skill, by Respondent Group *(continued)*

	Middle school/junior high				High school				College		
Reading skill	% Taught	Mean rating	SD	Rank	% Taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Synthesizing by...											
making connections across and between texts (e.g., by noting similarities and differences in two texts; by comparing information in a given text to other sources in a given field)	71	4.11	1.15	29	79	4.31	0.96	28	2.38	1.27	43
making connections between subjects or disciplines (e.g., literature and history)	76	4.09	1.17	30	84	4.32	0.91	27	2.54	1.16	41
drawing appropriate analogies	70	3.88	1.19	34	80	4.12	0.98	34	2.60	1.09	39
applying information gained from texts to new situations or problems	76	4.06	1.12	31	82	4.29	0.92	30	2.24	1.15	50
developing alternative hypotheses or solutions to those proposed in texts	50	3.57	1.25	45	61	3.82	1.17	49	2.64	1.27	38
Judging a text by...											
rating it against generally recognized standards of quality or excellence	31	3.20	1.27	61	49	3.54	1.26	60	3.00	1.24	27
using different critical lenses or stances (e.g., aesthetic, moral, political, philosophical)	21	2.94	1.25	64	41	3.47	1.25	62	3.08	1.28	25
determining its importance or value to oneself	49	3.39	1.28	54	63	3.83	1.17	48	2.78	1.22	33
assessing the risks and benefits of policies or actions it proposes or describes	27	3.09	1.35	62	43	3.50	1.29	61	2.75	1.24	34
Reading skills median rating	3.96					4.19			2.80		

Chapter 4
Science

State Standards

The state standards documents for science share significant areas of agreement encompassing both scientific knowledge (content knowledge drawn from life science, physical science, Earth/space science, biology, chemistry, and physics) and scientific processes. The EPAS Science Tests directly assess students' ability to comprehend, interpret, and use scientific information presented in a variety of ways. These skills include interpreting data; understanding scientific processes; and evaluating experiments, models, and assertions. Grade-level appropriate background knowledge covered in general, introductory science courses is needed to answer some of the questions. So the EPAS Science Tests continue to reflect state science standards—as well as the science standards in major documents from the American Association for the Advancement of Science (1989, 1993), the National Science Teachers Association (1992, 1995), and the National Research Council of the National Academy of Sciences (1995). In addition, the EPAS Science Tests closely align with the National Assessment of Educational Progress Science Framework in emphasizing similar content and cognitive dimensions of science, and in including the major topic areas and concepts identified in the framework.

There are a few scientific process skills within the state standards that are not directly measured on the EPAS Science Tests. These include designing and conducting experiments, communicating scientifically (oral and written), making judgments about the value of science, and understanding the impact of science on technology and society. However, the evidence is clear that the EPAS Tests have maintained the alignment with state curricula that was established during the redevelopment of the ACT Assessment through Project Silver (1980s) and that has continued to be verified by subsequent ACT National Curriculum Surveys.

Educator Surveys

ACT developed 10 Science curriculum surveys: 1 for middle school/junior high teachers, 4 (biology, chemistry, Earth/space science, and physics) for high school teachers, 1 for secondary science department chairs, and 4 (biology, chemistry, Earth science, and physics) for college faculty who teach entry-level courses. The primary source used in selecting these samples was Market Data Retrieval (MDR), a company specializing in the education market. Recipients were sampled from the MDR database using selection criteria provided by ACT to ensure that a variety of geographic regions and schools were represented.

Table 4.1 lists the Science courses that ACT requested MDR use as selection criteria. ACT mailed curriculum surveys to the number of teachers, faculty members, and department chairs indicated in the table. Altogether, 6,496 Science surveys were mailed across the 10 sample groups.

Table 4.1
Science Courses Used as MDR Sample Selection Criteria

Sample	Courses	Sample Size
Middle School/Junior High	*Science, Physical Science*	1,197
High School Biology	*Biology*	600
High School Chemistry	*Chemistry*	600
High School Earth Science	*Earth Science*	600
High School Physics	*Physics*	600
Postsecondary Biology	*Introduction to Biology, Introduction to Life Sciences, Introduction to Biology for Majors, Introduction to Biology for Nonmajors*	600
Postsecondary Chemistry	*General Chemistry for Majors, General Chemistry for Nonmajors, Introduction to Chemistry*	600
Postsecondary Earth/Space Science	*Geology and Human Ecology, Introduction to Earth Sciences, Introduction to Geology, Principles of Geology, Introduction to Astronomy*	600
Postsecondary Physics	*Fundamentals of Physics, General Physics, General Physics with Calculus Prerequisite, Introduction to Physical Science, Introduction to Physics, Physics for Nonmajors*	600
Department Chairs	*Middle School/Junior High Science, High School Science*	499

The survey respondents included individuals from all 50 states and the District of Columbia. The representation of the total respondent pool by region was 36.5% from the East, 32.4% from the Midwest, 12.4% from the Southwest, and 18.7% from the West. Analyses of the middle school/junior high, high school, and postsecondary respondent pools determined that they represented a wide variety of geographic locations and institutions. The department chair respondent pool, however, was found to be biased toward smaller schools. For this reason, survey results for the department chairs are not included in the discussion that follows. The numbers of surveys sent and the response rates are given in Table 4.2.

Table 4.2
Science Survey Types and Response Rates

Survey type	Number mailed	Number returned	Response rate
Middle School/Junior High	1,197	286	24%
High School	2,400	750	31%
Postsecondary	2,400	737	31%
Department Chairs	499	133	27%
Total	6,496	1,906	29%

ACT obtained the survey results, which are discussed below and are given in detail in Tables 4.6 and 4.7, by the following means. Respondents to all 10 surveys were provided with a list of 15 science skills related to scientific inquiry (e.g., *Translating data/information into a graph or diagram*). The first 11 skills on the survey are those directly assessed on the EPAS tests. The last 4 science skills were new to the 2003 curriculum survey. They are: *Designing a scientific investigation, Formulating models and predictions using scientific data, Communicating the results of a scientific investigation through writing properly organized reports,* and *Understanding and applying concepts of statistics and data analysis to the results of a scientific investigation.* These skills have been seen in many recent versions of state science standards documents and were added to the science skills section of the survey to get feedback from educators about their importance in secondary and postsecondary classes.

All of the surveys except the department chairs' survey also included a section that listed content topics. The middle school/junior high teachers responded to 202 content topics for three content areas: 68 for life science, 46 for Earth/space science, and 88 for physical science. The high school teachers and the college faculty responded to content topics for one of four content areas: biology (30 topics), chemistry (56 topics), Earth/space science (41 topics), or physics (57 topics).

For each science skill and content topic, the Grade 7–12 teachers were asked to indicate whether the skill or topic is taught and, if taught, to rate its importance on a scale of 1 to 5, where 1 represented *not important,* 3 represented *moderately important,* and 5 represented *very important.*

The task for the college faculty respondents was a bit different. Because the ACT Assessment is used for placement decisions and as a predictor of success during the first year of college, the expectations of the faculty of freshman-level courses regarding prerequisite science skills are important. To evaluate how well the ACT Assessment Science Test assesses the skills considered prerequisites to success in freshman-level courses, the college faculty were asked to reference one freshman-level science course they teach and to rate the importance of each listed skill as a prerequisite for that course, using the 5-point scale described above.

The Science surveys also asked respondents a variety of background questions. The middle school/junior high and high school respondents were asked to indicate the grade level of the students they taught and which course they taught (e.g., *Life Science, Earth or Earth/Space Science,* or *Physical Science* in middle school, or *Biology I, Chemistry I,* etc. in high school). Both groups were also asked how many years they had been teaching, the title of the primary textbook series they used, and how much time each week their students spent doing laboratory activities in their classes. Postsecondary science faculty were asked to indicate the course they taught (biology for non-science majors, biology for science majors, etc.), the general format of the course (e.g., lecture only, laboratory only, lecture and laboratory), and the primary textbook used in the course.

Science Skills and Content Topics. The **middle school/junior high teachers** indicated that all of the 15 science skills are more than moderately important (mean rating at or above 3), and that 10 of the 15 skills are more than quite important (mean rating at or above 4) in their classes. The science skills median rating is 4.17. Obviously, these respondents believe that the science skills listed on the survey are significant components of their classes.

In all three middle school/junior high subject areas (i.e., life science, Earth/space science, and physical science), the number of content topics listed on the survey that are taught by more than 80% of respondents is quite small. Only six topics, all in physical science, are taught by more than 80% of respondents. The six topics are scientific measurements and the metric system; physical and chemical changes; elements, compounds, and molecules; chemical symbols and formulas; mass, volume, and density; and mass and weight. However, all of the topics listed in all three subject areas were rated as more than moderately important (mean rating at or above 3), and large fractions of the total number of topics in each discipline were rated as more than quite important (mean rating at or above 4).

The **high school teachers** reported that all of the 15 science skills are more than moderately important in their classes (mean rating at or above 3) and that 14 of the 15 skills are more than quite important in their classes (mean rating at or above 4). Thus, the science skills' median rating is very high, at 4.32.

The high school teachers in each of the four disciplines (i.e., biology, chemistry, Earth/space science, and physics) reported that all of the topics listed are more than moderately important (mean rating at or above 3) in their classes. And large fractions of the total number of topics in each discipline were rated as more than quite important (mean rating at or above 4). Thus, all four of the content topics' median ratings are high, two of them (chemistry and physics) are above 4, and the other two are just below 4, at 3.90 and 3.77. The number of content topics reported to be taught by 70% or more respondents was quite small in biology (9 of the 30 topics) but much greater in chemistry (23 of the 56 topics), Earth/space science (24 of the 41 topics), and physics (31 of the 57 topics).

College faculty overall rated 11 of the 15 science skills as more than moderately important (mean rating at or above 3) as prerequisite knowledge for their freshman-level courses. Although college faculty generally rated the importance of the skills lower than did the other respondent groups, the overall median rating of the science skills by the college faculty was still fairly high, at 3.34.

College faculty in each of the four disciplines (i.e., biology, chemistry, Earth/space science, and physics) generally rated the majority of the topics listed as less than moderately important (mean rating below 3) as prerequisite knowledge for their freshman-level courses. Thus, all four of the content topics' overall median ratings are low: biology topics 2.46, chemistry topics 2.64, Earth science topics 2.59, and physics topics 2.80.

Table 4.3 presents the rank order of all 15 of the science skills for all three respondent groups. As can be seen, there is only a slight variation in the rankings of the top 5 skills.

Table 4.3
Ranking of Science Skills, by Respondent Group

Rank (1 = most important)	Middle school/ junior high school teachers	High school teachers	College faculty
1	Understanding basic scientific concepts or assumptions underlying given information	Translating data/information into a graph or diagram	Understanding the basic features of, or data points in, tables or graphs
2	Understanding the components of an experimental design or procedure (e.g., identify the control)	Understanding the basic features of, or data points in, tables or graphs	Understanding basic scientific concepts or assumptions underlying given information (tied with) Translating data/information into a graph or diagram
3	Understanding the basic features of, or data points in, tables or graphs	Determining whether data/information supports or is consistent with a stated hypothesis or conclusion	
4	Translating data/information into a graph or diagram	Understanding basic scientific concepts or assumptions underlying given information	Determining whether data/information supports or is consistent with a stated hypothesis or conclusion
5	Determining whether data/information supports or is consistent with a stated hypothesis or conclusion	Understanding the components of an experimental design or procedure (e.g., identify the control)	Selecting a hypothesis or conclusion that supports or is consistent with given data/information
6	Designing a scientific investigation	Selecting a hypothesis or conclusion that supports or is consistent with given data/information	Understanding the components of an experimental design or procedure (e.g., identify the control) (tied with) Predicting outcomes on the basis of data/information
7	Predicting outcomes on the basis of data/information	Communicating the results of a scientific investigation through writing properly organized reports	
8	Selecting a hypothesis or conclusion that supports or is consistent with given data/information	Predicting outcomes on the basis of data/information	Communicating the results of a scientific investigation through writing properly organized reports
9	Communicating the results of a scientific investigation through writing properly organized reports	Extending scientific concepts, hypotheses, or experimental procedures to new situations to gain new information	Extending scientific concepts, hypotheses, or experimental procedures to new situations to gain new information
10	Extending scientific concepts, hypotheses, or experimental procedures to new situations to gain new information	Designing a scientific investigation	Evaluating the similarities and differences, or the strengths and weaknesses, of experimental procedures or scientific viewpoints
11	Formulating models and predictions using scientific data	Formulating models and predictions using scientific data	Selecting a generalization or model that is consistent with given data/information
12	Understanding and applying concepts of statistics and data analysis to the results of a scientific investigation	Evaluating the similarities and differences, or the strengths and weaknesses, of experimental procedures or scientific viewpoints	Identifying an alternative way of testing a hypothesis or scientific viewpoint, or proposing an alternative way of producing the same experimental results
13	Selecting a generalization or model that is consistent with given data/information	Selecting a generalization or model that is consistent with given data/information	Designing a scientific investigation
14	Evaluating the similarities and differences, or the strengths and weaknesses, of experimental procedures or scientific viewpoints	Understanding and applying concepts of statistics and data analysis to the results of a scientific investigation	Formulating models and predictions using scientific data
15	Identifying an alternative way of testing a hypothesis or scientific viewpoint, or proposing an alternative way of producing the same experimental results	Identifying an alternative way of testing a hypothesis or scientific viewpoint, or proposing an alternative way of producing the same experimental results	Understanding and applying concepts of statistics and data analysis to the results of a scientific investigation

The survey results indicate that the science skills that the majority of respondents think are central to work in the classroom and lab are generally those that receive emphasis in the EPAS Science Tests. Although the design of the 2003 surveys differs from that of their 1998 predecessors, the 2003 results appear to be in fundamental agreement with the 1998 results on what knowledge and skills are important. A comparison of the 1998 and 2003 median ratings for science content topics for each science discipline revealed that there has been almost no change in those ratings between 1998 and 2003.

These data suggest that the high school and college science educators who responded to this survey believe that science skills, as a whole, are more important for success in their high school classes, or as prerequisites for entry-level college science classes, than are the content topics. Given that the EPAS tests give more emphasis to testing science skills, the data suggest that the EPAS tests assess what the survey respondents say is important for success in college.

Curriculum Consultants

ACT selected seven science educators from around the country to review the survey data. The reviewers were asked to study the tables of raw data, then answer five guiding questions about the survey results. Names of potential reviewers were solicited from ACT staff. Reviewer candidates were college science faculty and secondary science educators from across the country, some of whom had done work for ACT reviewing EPAS Science Test materials for content, fairness, or grade-level appropriateness. Other candidates were unfamiliar, or less familiar, with the EPAS tests. Table 4.4 lists the seven science reviewers.

The reviewers agreed that the content and science skills assessed on the EPAS Science Tests reflect the current Grades 7–12 science curricula. They also agreed that the EPAS Science Tests assess science skills and cover content topics important for success in college. However, there was some disagreement about whether the EPAS Science Tests, as they exist today, can adequately test both science skills and content knowledge. Some reviewers suggested using the current passage-based, multiple-choice exam, but limiting the amount of science content tested. Others thought content should be tested with a separate, discrete multiple-choice exam, while keeping the present EPAS tests in their current format to test science skills. Some other reviewers suggested adding a writing component to assess a student's ability to *"Communicate the results of a scientific investigation through writing properly organized reports."*

The reviewers also emphasized that, given the continuing evolution of science education and the technological changes affecting it, ACT must continue to closely monitor science curricula and standards if it is to maintain its commitment to the content validity of the EPAS Science Tests. Some curriculum trends mentioned by the reviewers included a change in the middle school curricula from single-discipline, full-year science courses to three-year sequences of integrated science classes. Another significant trend at the middle school level is the incorporation of more inquiry-based, "hands-on" science activities and a reduction in lecture-based classes.

Several reviewers expressed general concerns about the uses of large-scale assessments. They felt that these assessments should be used for more than just showing accountability. Such exams should be designed primarily to assess student achievement, as do the EPAS Science Tests.

Table 4.4
ACT's 2002 Science Curriculum Survey Reviewers

Name	Title and affiliation
Ms. Kathryn Barclay	Science Teacher, Dulles Middle School, Sugar Land, Texas
Dr. Barbara Christie-Pope	Associate Professor of Biology, Environmental Studies, Cornell College, Mount Vernon, Iowa
Dr. John Fix	Dean of the College of Science, University of Alabama at Huntsville, Huntsville, Alabama
Ms. Francisca Garner	Science Teacher, Eisenhower High School, Lawton, Oklahoma
Mr. C. Steven Storm	Mathematics & Science Instructor, Arkansas State University-Heber Springs, Heber Springs, Arkansas
Ms. Cynthia Taylor	Science Teacher, Monterey High School, Monterey, Tennessee
Dr. Richard Treptow	Professor of Chemistry, Chicago State University, Chicago, Illinois

Science Test Specifications

The EPAS Science Tests measure the student's interpretation, analysis, evaluation, reasoning, and problem-solving skills required in the natural sciences. A test for a given program is made up of five to seven test units, each of which consists of some scientific information (the stimulus) and a set of multiple-choice test items. The use of calculators is not permitted on the Science Tests. Table 4.5 summarizes the test specifications for the EXPLORE, PLAN, and ACT Assessment Science Tests. Under the "Format" heading are the numbers (and proportions) of test questions associated with each of the three types of presentations used in the three tests. Under the "Cognitive Level" heading are the distributions of questions assessing the three cognitive levels. Finally, under the "Subject Matter" heading are the distributions of test questions by content domain being assessed. The terms used in the tables are defined in the next section.

Table 4.5
Science Test Specifications

	Testing program		
Format	**EXPLORE**	**PLAN**	**ACT Assessment**
Data Representation	12 (.43)	10 (.33)	15 (.38)
Research Summaries	10 (.36)	14 (.47)	18 (.45)
Conflicting Viewpoints	6 (.21)	6 (.20)	7 (.17)
Total	**28**	**30**	**40**
Cognitive level			
Understanding	12 (.43)	9 (.30)	7 (.18)
Analysis	10 (.36)	13 (.43)	20 (.50)
Generalization	6 (.21)	8 (.27)	13 (.32)
Total	**28**	**30**	**40**
Subject matter			
Life Science	3		
Physical Science	2		
Earth/Space Science	1	1–2*	1–2*
Biology		1–2*	1–2*
Chemistry		1–2*	1–2*
Physics		1–2*	1–2*
Total	**6**	**5**	**7**

*At least one topic is required in this content area, and some test forms may have two topics. No more than two topics in a particular content area are allowed.

The following section provides detailed descriptions of the materials used in the EPAS Science Tests. These descriptions are presented in the order in which the information was summarized in Table 4.5: first the formats for the stimulus material, then the definitions of the cognitive levels being assessed, and finally lists of the content included in the fields of science covered at each test level.

Science Continuum Stimulus Material, Cognitive Level, and Content Area Descriptions

Stimulus Material

Each stimulus used in the Science Tests as the basis for the test questions follows one of three formats. These formats are very specific in their intent and style, each being used to tap a specific subset of scientific reasoning skills.

Data representation format. The data representation format is intended to test the examinee's ability to understand, evaluate, and interpret information presented in a graphic or tabular format. The information may consist of any type of data that can be presented with minimal explanation. Examples include the results of simple experiments, observations, summarized data, figures, or flowcharts.

Research summaries format. The research summaries format is intended to evaluate an examinee's abilities to comprehend, evaluate, analyze, and interpret the design of experiments. In particular, the skills to be assessed using this format include the following:

- The understanding of the premise of the experiment (observation, confirmation, or hypothesis testing)
- The relationship of the design to the premise
- The understanding of control groups
- Variations in experimental designs
- Weaknesses of the experiment due to assumptions or limitations embedded in the design

Almost anything that relates to how scientists view experiments is a valid topic in this type of format. However, since the data representation format covers the aspects of interpretation of data, the tabular or graphic presentation of the experiments alone is not a major point of consideration. The simulated research studies are of sufficient complexity to allow significant comparisons of results. Often, a number of linked, related experiments are presented that build on each other and provide an extended simulation of several research studies.

Conflicting viewpoints format. The conflicting viewpoints format is intended to test the examinee's ability to evaluate two or more alternative theories, hypotheses, or viewpoints on a specific, observable phenomenon. This phenomenon may be a simple observation or a more complex process. The alternative viewpoints disagree in some clear fashion that is plausible, but they need not necessarily be based on a contemporary scientific controversy. The main restriction is that they be logical and complete. The alternative viewpoints are based on realistic assumptions and have logical conclusions.

Cognitive Levels

The questions in the Science Tests are classified according to three primary cognitive levels: understanding, analysis, and generalization. Within each of the three major cognitive classifications there are a number of subclassifications. These are presented to clarify the types of test questions that are within the major categories, but they are not meant to provide an exhaustive list. Some of the subclassifications do not apply to some of the stimulus formats. For example, a classification referring to experimental design is not appropriate for a data representation format. The stimulus formats that support questions with each subclassification are coded at the end of each description using DR for data representation, RS for research summaries, and CV for conflicting viewpoints.

Understanding. Understanding questions test students' ability to comprehend the information presented and, to a limited extent, their understanding of how it fits into the general scheme of the particular stimulus format. Examples of this ability include comprehending how the information in a bar graph is organized, understanding the control group's function in an experiment, and identifying unstated assumptions and the concept that serves as the basis for a particular theory. A question in the understanding classification does not merely ask the student to understand what is written, but to understand how that information is related to other parts of the material provided in the stimulus. An understanding question specifically deals with only a small part of the material in the stimulus, such as a single data point, graph axis, hypothesis, or experimental step.

Understanding—The ability to:

- Explain, describe, identify, or compare the basic features of, and concepts related to, the provided information. (DR, RS, CV)
- Explain, describe, identify, or compare the components of the experimental design or process. (RS)
- Explain, describe, identify or compare the basic features or data points in graphs, charts, or tables. (DR)
- Explain, describe, or identify basic scientific concepts or assumptions underlying the provided information. (DR, RS, CV)
- Select the appropriate translation of the provided information into a graph, figure, or diagram. (DR, RS, CV)

Analysis. Analysis questions should go beyond the level of understanding questions in testing the student's ability to relate a number of components of the presented material to each other on a higher, more abstract level. Examples of this question type include relating hypotheses to experimental design or data, and evaluating how a viewpoint is related to another viewpoint or to an observable phenomenon. Essentially, the student is required to exhibit the ability to see how each piece of information in the presentation fits in with the rest of the stimulus and what importance each piece has in reference to the topic. Often, an analysis question will prompt a student to carefully pick apart the details presented and piece them back together to get an overall view of the presented topic. An analysis question typically deals with a major portion of the presented information, such as a graphed relationship, one or more experiments, or one or more viewpoints. An analysis question does not extend beyond the scope of the presented material.

Analysis—The ability to:

- Critically examine the relationships between the information provided and the conclusions drawn or the hypotheses developed. (DR, RS, CV)
- Determine whether information or results support or are consistent with a point of view, hypothesis, or conclusion. (DR, RS, CV)
- Determine whether a hypothesis or conclusion supports or is consistent with a point of view, the results of a single experiment, or the information presented in a single graph or table. (DR, RS, CV)
- Evaluate experimental procedures, viewpoints, or theories for their strengths, weaknesses, similarities, or differences. (RS, CV)
- Specify alternative ways of testing the point of view or hypothesis, or specify alternative ways of producing the same results. (RS, CV)

Generalization. Generalization questions test the student's ability to see how the stimulus material relates to the rest of the world. A generalization question may ask for a general model of a scientific concept that is embedded in the presented data (for example, deduce a gas law from a set of data), how the results of an experiment could be used to assist someone in resolving a problem in the real world, or how a theory could be modified to account for some new, unforeseen data or phenomena. While generalization questions may not always be the most difficult for a student, they are intended to demand that the student assimilate all of the material presented and extend discovered concepts to new situations.

Generalization—The ability to:

- Generalize from given information to gain new information, generate a model, or make predictions. (DR, RS, CV)
- Extend concepts, procedures, or hypotheses to new situations to gain new information. (RS, CV)
- Generalize beyond the given information to a broader context, or generate a model consistent with the provided information. (DR, RS, CV)
- Predict outcomes on the basis of the provided information. (DR, RS, CV)

Content Areas

The content areas used to assess Science skills parallel the content courses commonly taught at Grades 7–12, and at the entry level at colleges and universities. Each test activity uses stimulus materials from one of these areas. Materials are produced specifically for the Science Tests. They are required to match the level of complexity of those used in the classroom. Often, students are confronted with a new situation to engage their reasoning skills.

The topics included in each content area are summarized below.

Life Science. The stimulus materials and questions in this content area cover such topics as biology, botany, ecology, health, human behavior, and zoology.

Physical Science. The stimulus materials and questions in this content area cover such topics as simple chemical formulas and equations and other basic chemistry, weights and measures, and basic principles of physics.

Earth/Space Science. The stimulus materials and questions in this content area cover such topics as geology, meteorology, astronomy, environmental science, and oceanography.

Biology. The stimulus materials and questions in this content area cover such topics as cell biology, botany, zoology, microbiology, ecology, genetics, and evolution.

Chemistry. The stimulus materials and questions in this content area cover such topics as atomic theory, inorganic chemical reactions, chemical bonding, reaction rates, solutions, equilibriums, gas laws, electrochemistry, and properties and states of matter.

Physics. The stimulus materials and questions in this content area cover such topics as mechanics, energy, thermodynamics, electromagnetism, fluids, solids, and light waves.

Table 4.6

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Science Skill, by Respondent Group

	Middle school/junior high				High school					College		
Science skill	% Taught	Mean rating	SD	Rank	% Taught	% Taught prior	Mean rating	SD	Rank	Mean rating	SD	Rank
Understanding the components of an experimental design or procedure (e.g., identify the control)	94	4.32	0.97	2	71	24	4.43	0.84	5	3.35	1.25	6
Understanding the basic features of, or data points in, tables or graphs	93	4.31	0.93	3	78	18	4.53	0.74	2	3.91	1.08	1
Understanding basic scientific concepts or assumptions underlying given information	95	4.34	0.86	1	78	16	4.44	0.82	4	3.78	1.12	2
Translating data/information into a graph or diagram	93	4.26	0.89	4	79	18	4.54	0.75	1	3.78	1.17	2
Determining whether data/information supports or is consistent with a stated hypothesis or conclusion	91	4.21	0.97	5	78	16	4.45	0.83	3	3.70	1.15	4
Selecting a hypothesis or conclusion that supports or is consistent with given data/information	88	4.17	1.01	8	71	21	4.40	0.86	6	3.54	1.17	5
Evaluating the similarities and differences, or the strengths and weaknesses, of experimental procedures or scientific viewpoints	70	3.69	1.07	14	59	18	4.15	1.01	12	3.12	1.18	10
Identifying an alternative way of testing a hypothesis or scientific viewpoint, or identifying an alternative way of producing the same experimental results	62	3.48	1.11	15	46	18	3.88	1.08	15	2.90	1.14	12
Selecting a generalization or model that is consistent with given data/information	75	3.76	0.96	13	57	17	4.10	1.01	13	3.10	1.14	11
Predicting outcomes on the basis of data/information	95	4.18	0.89	7	77	14	4.32	0.88	8	3.35	1.17	6
Extending scientific concepts, hypotheses, or experimental procedures to new situations to gain new information	78	4.02	1.01	10	64	12	4.24	0.97	9	3.26	1.19	9
Designing a scientific investigation	86	4.19	0.92	6	56	18	4.19	1.02	10	2.82	1.25	13
Formulating models and predictions using scientific data	81	3.98	0.96	11	60	14	4.17	0.99	11	2.80	1.14	14
Communicating the results of a scientific investigation through writing properly organized reports	81	4.12	0.99	9	72	13	4.37	0.92	7	3.34	1.31	8
Understanding and applying concepts of statistics and data analysis to the results of a scientific investigation	66	3.79	1.09	12	55	11	4.10	1.03	14	2.71	1.24	15
Science skills median rating		4.17					4.32			3.34		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group

	Middle school/junior high				
Content topic	% Taught	% Not taught	Mean rating	SD	Rank
Life science					
Flowering plants	49	51	3.81	0.96	45
Non-flowering plants	46	54	3.67	1.06	50
Structure and function of roots	47	53	3.76	1.00	47
Structure and function of stems	47	53	3.74	0.99	49
Structure and function of leaves	48	52	3.86	0.96	41
Structure and function of flowers	48	52	3.87	0.88	39
Structure and function of seeds	48	52	3.81	0.93	44
Life cycles	60	40	4.05	0.92	31
Photosynthesis	67	33	4.37	0.80	4
Circulatory	50	50	4.45	0.84	2
Digestive	46	54	4.37	0.92	5
Excretory	40	60	4.27	0.93	12
Hormonal	36	64	4.09	1.06	26
Lymphatic	34	66	4.12	1.07	21
Muscular	44	56	4.33	0.94	7
Nervous	46	54	4.22	1.01	15
Respiratory	46	54	4.31	0.97	8
Reproductive	42	58	4.29	0.97	11
Skeletal	44	56	4.31	0.97	9
Bacteria	57	43	4.18	0.91	17
Protists	55	45	4.10	0.95	25
Fungi	54	45	4.06	0.97	28
Arthropods	46	53	3.85	1.07	42
Other invertebrates	47	53	3.88	1.06	38
Genes and chromosomes	67	33	4.35	0.97	6
DNA	64	36	4.41	0.94	3
Mendelian genetics	58	42	4.25	1.02	13
Genetic engineering	49	51	3.96	1.16	33
Ecosystems	63	37	4.11	0.98	24
Food chains, webs, and pyramids	61	39	4.13	1.00	20
Niches and habitats	56	44	3.99	1.04	32
Limiting factors	50	50	3.91	1.06	34
Succession	45	55	3.87	1.04	40
Biomes	49	51	3.89	1.08	37
Competition and predation	55	45	3.90	1.09	36
Population growth	51	49	3.85	1.14	43
Fossils	52	48	3.52	1.18	53
Geologic time	52	48	3.56	1.13	52
Adaptation	61	39	4.05	0.96	29
Natural selection	57	43	4.05	0.99	30
Nutrition	38	62	4.06	1.12	27
Immunity	42	58	4.15	1.03	19
Disease control	42	58	4.23	0.94	14
Viruses	51	49	4.19	0.99	16
Mitosis and meiosis	63	37	4.31	0.90	10
Development	53	47	4.17	0.88	18
Cell structure and function	69	31	4.49	0.76	1
Carbohydrates	46	54	3.80	1.08	46
Lipids	43	57	3.63	1.09	51
Proteins and amino acids	51	49	3.76	1.13	48
Osmosis	62	38	4.11	0.97	23
Diffusion	63	37	4.12	1.00	22
Metabolism	53	47	3.91	1.05	35
Life science topics median rating			4.06		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	Middle school/junior high				
Content topic	% Taught	% Not taught	Mean rating	SD	Rank
Earth/space science					
Map reading and interpretation	55	45	3.96	1.06	33
The geologic time scale	57	43	3.77	1.01	44
Types of fossils and fossilization	51	49	3.70	1.02	46
Properties of matter	75	25	4.28	0.87	6
Minerals and their properties	66	33	4.17	0.92	16
Rocks and their properties	63	37	4.07	0.96	28
The rock cycle	63	37	4.21	0.92	11
Weathering processes	64	36	4.24	0.87	8
Erosion and agents of erosion	61	39	4.13	0.93	19
Deposition	60	40	4.08	0.95	27
Groundwater	54	46	4.09	0.96	26
Global plate tectonics	72	28	4.33	0.87	4
Volcanism	68	32	4.23	0.95	10
Earthquakes	68	32	4.27	0.89	7
Earth's interior	68	32	4.15	0.95	18
Types of natural resources	64	36	3.90	1.06	37
Fossil fuels	63	37	3.87	1.09	38
Alternative energy sources	59	41	3.92	1.14	35
Air, water, soil pollution	62	38	4.05	1.01	31
Recycling	60	40	3.94	1.05	34
The composition of air	66	34	4.09	1.08	25
Earth's atmosphere	64	36	4.23	0.98	9
Air pressure	61	39	4.19	1.02	13
Global and local winds	54	46	4.10	1.09	23
Relative humidity and dew point	54	46	4.07	1.02	30
Clouds and precipitation	59	41	4.12	1.03	21
Weather prediction	53	47	4.13	0.96	20
Weather patterns	57	43	4.18	1.01	14
Climate	57	43	4.02	1.05	32
Ocean currents	41	59	3.77	1.01	43
Properties of ocean water	38	62	3.78	1.02	42
Topography of the ocean floor	41	59	3.78	1.01	41
Tides	50	50	3.78	0.97	40
Waves	46	54	3.72	0.97	45
The planet Earth	67	33	4.37	0.87	2
The Earth in space	65	35	4.36	0.90	3
Our solar system's formation	64	36	4.18	0.96	15
Motions of the planets	62	38	4.16	1.05	17
Earth's Moon	64	36	4.31	0.86	5
Solar and lunar eclipses	62	38	4.21	0.88	12
Comets, asteroids, meteors	60	40	4.07	0.93	29
The Sun and its energy	65	35	4.37	0.79	1
Telescopes to study the universe	53	47	3.83	1.13	39
Galaxies	56	44	3.92	1.11	36
Stars	57	43	4.11	0.99	22
The universe and its formation	59	41	4.09	0.98	24
Earth/space science topics median rating			4.09		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	Middle school/junior high				
Content topic	% Taught	% Not taught	Mean rating	SD	Rank
Physical science					
Scientific measurements; metric system	89	11	4.50	0.77	1
Physical and chemical changes	80	20	4.50	0.80	2
Elements, compounds, and molecules	83	16	4.44	0.86	5
Mass, volume, and density	87	13	4.49	0.84	3
Chemical symbols and formulas	80	20	4.30	0.93	12
Atoms: protons, electrons, and neutrons	79	21	4.47	0.83	4
Forces within the atom	63	37	4.03	1.07	26
Energy levels within the atom	65	35	4.13	1.03	21
Periodic table; atomic number, mass number	77	23	4.36	0.94	9
Types of chemical bonds	61	39	4.06	1.07	24
Chemical reactions: reactants and products	61	39	4.29	0.87	13
Balancing chemical equations	57	43	3.83	1.22	51
Endothermic and exothermic reactions	55	45	3.92	1.08	41
Rates of chemical reactions	42	58	3.69	1.19	59
Solutions: solubility and concentration	57	43	3.88	1.10	47
Polarity	25	75	3.27	1.40	88
Freezing point depression; boiling point elevation	39	61	3.68	1.24	62
Acids and bases; salts	49	51	3.83	1.11	50
pH scale	52	48	3.88	1.10	46
Radioactive elements and radioactivity	41	58	3.57	1.16	70
Speed, velocity, and acceleration	67	33	4.25	0.99	15
Momentum	63	37	4.14	1.07	20
Newton's three laws of motion	69	31	4.42	0.94	6
Friction	70	30	4.34	0.98	11
Gravity	76	24	4.35	0.90	10
Mass and weight	83	17	4.39	0.91	8
Projectile and orbital motion	44	56	3.71	1.16	57
Fluid pressure	40	60	3.62	1.14	67
Buoyancy; Archimedes' principle	51	49	4.00	1.09	33
Bernoulli's principle	44	56	3.75	1.25	54
Work, power, and efficiency	54	46	4.04	1.08	25
Simple machines (levers, pulleys, etc.)	50	50	4.23	1.05	16
Mechanical, heat, chemical, electromagnetic, and nuclear energy	54	46	4.10	1.02	22
Kinetic and potential energy	64	36	4.41	0.92	7
Energy conversions and conservation of energy	60	40	4.26	0.99	14
Temperature and molecular motion	61	38	4.21	0.99	17
Kelvin scale	39	61	3.40	1.20	83
Heat transfer: conduction, convection, and radiation	58	41	4.17	0.98	18
Specific heat; amount of heat gained or lost	36	64	3.69	1.09	60
Melting, freezing, and boiling points	68	32	4.15	0.89	19
Heats of fusion and vaporization	33	67	3.64	1.11	66
Thermal expansion	36	64	3.65	1.15	64
Heating and cooling systems; heat engines	25	75	3.35	1.05	85
Electric charge	39	61	4.02	1.12	29
Electric fields	32	68	3.95	1.22	38
Static electricity; charging an object	40	60	3.99	1.15	34
Conductors and insulators	42	58	4.02	1.10	30
Voltage, current, and resistance; Ohm's law	30	70	4.03	1.20	28

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	Middle school/junior high				
Content topic	% Taught	% Not taught	Mean rating	SD	Rank
Electrochemical cells; batteries	29	71	3.70	1.27	58
Electrical circuits	32	68	4.01	1.28	31
Electrical energy and power	34	66	3.96	1.14	37
Magnetism: magnetic poles and fields	37	63	3.81	1.23	52
Earth as a magnet; compasses	39	61	3.73	1.11	55
Magnetic effects of electricity; motors	27	73	3.65	1.31	65
Electromagnetic induction; generators	23	77	3.51	1.25	75
Transformers	20	79	3.28	1.27	87
Types of waves: transverse and longitudinal	39	61	3.99	1.02	35
Amplitude, wavelength, and frequency	44	56	3.91	1.04	44
Speed of waves	42	58	3.86	1.01	49
Reflection and refraction	44	56	4.03	0.99	27
Diffraction	35	65	3.91	1.01	42
Constructive and destructive interference	25	75	3.43	1.27	82
Transmitting sound	31	69	3.53	1.22	73
Intensity and loudness	28	72	3.56	1.27	72
Frequency (pitch); sound quality (timbre)	30	70	3.62	1.22	68
Doppler effect	38	62	3.67	1.18	63
Resonance	23	77	3.45	1.25	80
Light energy: photons	28	72	3.72	1.29	56
Electromagnetic waves	41	59	4.01	1.05	32
Electromagnetic spectrum	44	56	4.08	1.09	23
Separating white light: prisms	42	58	3.86	1.05	48
Transmittance and absorbance	23	77	3.49	1.28	76
Transparent, translucent, and opaque surfaces	28	72	3.61	1.26	69
Primary and complementary colors and pigments	25	75	3.52	1.23	74
Incandescent and fluorescent light	23	77	3.46	1.19	79
Plane, concave, and convex mirrors	30	69	3.56	1.14	71
Concave and convex lenses	34	66	3.79	1.05	53
Cameras, telescopes, and microscopes	34	66	3.68	1.06	61
Lasers; fiber optics	27	73	3.47	1.19	77
Fossil fuels	58	42	3.91	1.03	43
Solar energy; wind and water power	54	46	3.93	1.13	40
Nuclear energy	49	51	3.94	1.19	39
Alternative energy sources	55	45	3.90	1.14	45
Pollution and conservation	61	39	3.98	1.06	36
Petroleum fuels and fractional distillation	21	79	3.46	1.39	78
Polymers	21	79	3.39	1.35	84
Electronic devices (transistors, integrated circuits, etc.)	14	86	3.29	1.43	86
Communication devices (telephones, computers, etc.)	22	78	3.45	1.38	81
Physical science topics median rating			3.90		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Biology									
Structure and function of biologically important molecules (e.g., proteins, lipids, carbohydrates, and nucleic acids)	89	5	6	4.37	0.91	5	3.64	1.31	4
Structure and function of cells (e.g., organelles, membrane structure, cytoplasm)	90	9	1	4.70	0.65	1	3.89	1.21	1
Biochemistry of life processes (e.g., Krebs cycle, electron transport)	70	10	20	3.99	1.14	8	3.09	1.34	8
Structure and function of the circulatory system	62	11	27	3.91	0.95	14	2.41	1.19	17
Structure and function of the digestive system	62	12	26	3.93	0.95	12	2.38	1.20	21
Structure and function of the skeletal and muscular systems	59	13	29	3.97	0.97	10	2.32	1.16	23
Structure and function of the respiratory system	63	12	26	3.91	0.98	14	2.38	1.21	20
Structure and function of the excretory system	55	12	33	3.81	0.97	22	2.29	1.17	26
Structure and function of the nervous system	61	11	28	3.92	0.98	13	2.38	1.20	19
Structure and function of the endocrine system	52	11	37	3.75	1.02	24	2.32	1.16	23
Structure and function of the reproductive system	56	10	33	3.80	1.02	23	2.43	1.21	16
Structure and function of the immunological system	54	9	36	3.84	0.97	20	2.28	1.18	27
Sensory organs	44	14	42	3.58	1.11	29	2.24	1.13	28
Human health (e.g., nutrition, aging, diseases)	41	30	29	3.68	1.21	25	2.50	1.17	14
Microbiology (e.g., bacteria, viruses)	74	11	14	3.87	1.08	17	2.67	1.07	12
Plant anatomy (e.g., stems, roots, flowers)	61	18	20	3.67	1.16	26	2.34	1.12	22
Plant physiology (e.g., transport)	58	19	23	3.60	1.26	28	2.17	1.09	29
Plant reproduction (e.g., life cycles, pollination, seeds, growth and development)	61	19	20	3.65	1.22	27	2.31	1.10	25
Plant nutrition (e.g., essential nutrients, photosynthesis)	61	16	23	3.86	1.13	18	2.40	1.17	18
Cell division (e.g., mitosis and meiosis)	85	13	2	4.54	0.81	4	3.77	1.17	2
Embryology (e.g., fertilization, development)	59	11	30	3.85	1.06	19	2.50	1.10	15
Mendelian genetics (e.g., Mendel's Laws, genetic crosses)	82	13	5	4.66	0.65	2	3.65	1.31	3
Molecular genetics (e.g., protein synthesis, DNA replication, genetic engineering)	84	10	6	4.60	0.71	3	3.38	1.36	6
Diversity of life (e.g., kingdoms, classification systems)	83	14	3	4.12	0.97	6	3.32	1.29	7
Evolution (e.g., natural selection, adaptations, speciation)	74	15	11	4.10	1.05	7	3.54	1.41	5
Animal behavior	43	12	45	3.34	1.21	30	2.02	0.99	30
Population ecology (e.g., habitats, niches, population growth)	60	14	26	3.88	1.22	16	2.69	1.26	11
Species interactions (e.g, competition, predation, mutualism)	62	14	23	3.84	1.22	21	2.65	1.26	13
Ecosystems (e.g., food chains, energy pyramids, succession)	62	18	20	3.97	1.22	9	2.96	1.34	10
Human impact on the environment (e.g., pollution, greenhouse effect)	61	15	24	3.95	1.19	11	3.00	1.32	9
Biology content topics median rating				3.90			2.46		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Chemistry									
Units of measurement; metric system	84	16	0	4.54	0.78	4	4.39	0.99	1
Classification and properties of matter	87	13	0	4.24	0.90	10	3.69	1.10	6
Density	84	16	0	4.03	0.97	21	3.61	1.06	10
Atoms, molecules, ions; mole concept	92	7	0	4.90	0.36	1	4.24	1.10	2
Chemical formulas and equations	93	7	0	4.88	0.41	2	4.12	1.15	3
Stoichiometry and percent yield	92	4	4	4.70	0.64	3	3.69	1.36	6
Heat, enthalpy, state functions	68	2	30	3.88	1.01	24	2.91	1.42	22
Ideal gas law; kinetic molecular theory	85	4	11	4.42	0.80	8	3.23	1.32	15
Electron configurations, valence electrons	93	6	1	4.43	0.82	7	3.54	1.33	12
Chemical bond formation	89	6	5	4.45	0.75	5	3.62	1.30	9
Bonding theories	76	4	20	4.07	0.99	17	3.01	1.32	21
Polarity, electronegativity	88	5	7	4.17	0.91	12	3.22	1.37	16
Kelvin temperature scale	87	9	4	4.13	0.96	15	3.56	1.24	11
Phase changes	85	7	7	4.14	0.90	14	3.20	1.22	17
Phase diagrams	65	6	29	3.49	1.02	39	2.12	1.14	43
Units of concentration	84	2	14	4.20	0.87	11	3.77	1.22	4
Colligative properties	59	3	37	3.66	1.05	32	2.61	1.24	29
Reaction rates	52	1	47	3.82	1.05	28	2.74	1.40	24
Reaction mechanisms	40	1	59	3.36	1.18	43	2.22	1.29	41
Catalysts; enzymes	55	6	40	3.49	1.05	40	2.42	1.23	36
Chemical equilibria	62	1	37	4.10	1.08	16	3.12	1.49	19
Bronsted acid/base theory	73	2	25	4.06	0.98	18	3.39	1.39	13
Lewis acid/base theory	62	3	35	3.85	1.10	26	2.72	1.36	25
pH scale	83	7	9	4.44	0.79	6	3.76	1.28	5
Acid/base reactions	83	5	12	4.34	0.82	9	3.65	1.29	8
Common ion effect and buffer solutions	36	3	60	3.56	1.16	36	2.68	1.37	27
Acid/base titration	76	2	22	4.16	0.88	13	3.18	1.32	18
Acid/base indicators	79	4	17	3.95	0.95	23	2.80	1.21	23
Solubility product	43	1	56	3.60	1.15	35	2.49	1.41	33
Qualitative analysis	44	3	52	3.61	1.18	33	2.26	1.18	40
Spontaneity and entropy	37	2	61	3.33	1.25	46	2.50	1.42	32
2nd law of thermodynamics	35	2	63	3.41	1.19	42	2.48	1.38	34
Gibbs free energy	25	2	74	3.26	1.34	49	2.45	1.48	35
Oxidation/reduction reactions	66	0	33	4.04	1.04	19	3.25	1.45	14

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Electrochemical cells	32	3	65	3.47	1.15	41	2.59	1.32	30
Batteries and storage cells	25	5	70	3.09	1.16	51	2.32	1.18	38
Electrolysis	41	4	55	3.34	1.23	45	2.29	1.23	39
Corrosion	39	3	59	3.35	1.17	44	2.02	1.04	48
Chemistry of Group 1A, 2A	77	5	17	3.87	1.08	25	2.69	1.24	26
Metals, metalloids, nonmetals	81	8	11	4.03	1.01	20	3.08	1.20	20
Chemistry of Groups 5A, 6A, 7A	70	5	24	3.85	1.12	27	2.58	1.22	31
The Noble gases	79	8	14	3.96	1.09	22	2.66	1.22	28
Basic organic nomenclature	55	3	42	3.72	1.14	29	2.08	1.30	45
Organic molecules/structures	48	3	49	3.68	1.19	31	2.15	1.34	42
Functional groups	42	2	56	3.50	1.24	38	2.06	1.34	47
Petroleum and its products	23	5	72	2.97	1.21	53	1.63	0.93	55
Molecular stereochemistry	16	2	82	2.89	1.28	56	1.88	1.17	51
Amino acids, proteins	14	10	75	2.95	1.32	54	1.78	1.22	53
Carbohydrates, nucleic acids	13	11	76	2.93	1.32	55	1.75	1.21	54
Synthetic polymers	21	4	75	2.99	1.20	52	1.63	0.93	55
Chemistry of transition metals	42	4	55	3.30	1.18	47	1.86	1.04	52
Spectroscopy/absorption	33	3	63	3.26	1.15	50	2.10	1.18	44
Nature of radioactivity	55	4	40	3.69	1.09	30	2.38	1.23	37
Rates of nuclear decay	45	4	50	3.51	1.12	37	2.08	1.16	45
Nuclear fission/fusion	50	5	45	3.61	1.08	34	2.01	1.10	49
Radiochemical dating	42	3	55	3.28	1.18	48	1.91	1.08	50
Chemistry content topics median rating				3.77			2.64		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Earth/space science (or Earth science)									
Map reading and interpretation	80	9	11	4.23	0.95	18	2.72	1.24	17
The geologic time scale	73	9	18	3.86	1.11	34	2.76	1.41	14
Types of fossils	61	13	26	3.25	1.07	41	1.78	1.02	41
Fossilization	67	11	22	3.53	1.04	40	1.90	1.15	39
Interpretation of fossils	60	9	32	3.58	1.07	39	1.87	1.11	40
Properties of matter	59	35	6	4.15	1.12	21	3.36	1.22	1
Minerals and their properties	87	7	6	4.46	0.79	5	3.01	1.51	7
Rocks and their properties	89	7	4	4.43	0.85	7	3.07	1.53	6
The rock cycle	88	8	3	4.44	0.86	6	3.15	1.53	4
Biogeochemical cycles (carbon, nitrogen, water, etc.)	58	19	22	3.73	1.09	37	2.66	1.38	19
Weathering processes	86	8	5	4.20	0.96	20	2.97	1.41	8
Soil formation and soil properties	71	10	18	3.76	1.08	36	2.47	1.30	23
Erosion and agents of erosion	85	10	5	4.30	0.89	16	2.93	1.42	9
Deposition	83	10	7	4.04	1.03	26	2.82	1.39	12
Groundwater	80	8	12	4.25	0.99	17	2.74	1.50	16
Landform creation	82	7	10	4.08	0.94	23	2.70	1.40	18
Global plate tectonics	91	6	3	4.76	0.54	1	3.32	1.61	2
Volcanism	85	8	6	4.51	0.78	3	3.21	1.54	3
Earthquakes	90	6	4	4.67	0.60	2	3.11	1.56	5
Earth's interior	90	6	3	4.49	0.76	4	2.91	1.50	11
Types of natural resources	63	13	24	3.97	1.19	29	2.59	1.40	21
Fossil fuels	60	15	24	3.93	1.18	30	2.43	1.39	26
Alternative energy sources	55	13	32	4.02	1.11	27	2.23	1.29	33
Conservation and preservation	55	12	32	4.07	1.12	25	2.29	1.38	32
Air, water, soil pollution	67	11	22	4.10	1.09	22	2.41	1.35	27
Recycling	44	22	33	3.87	1.28	33	2.00	1.25	38
Population growth	28	24	48	3.64	1.34	38	2.20	1.32	35
The composition of air	82	11	8	4.34	0.85	13	2.77	1.54	13
Earth's atmosphere	88	6	6	4.39	0.90	10	2.92	1.59	10
Air pressure	80	13	8	4.40	0.90	8	2.51	1.47	22
Global and local winds	80	11	10	4.31	0.93	14	2.46	1.51	24
Relative humidity and dew point	78	11	11	4.37	0.82	11	2.21	1.49	34
Clouds and precipitation	82	10	8	4.39	0.82	9	2.44	1.53	25
Weather prediction	77	12	11	4.31	0.95	15	2.09	1.40	37

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Weather patterns	80	12	8	4.35	0.89	12	2.31	1.46	31
Climate	75	14	11	4.21	1.02	19	2.76	1.56	14
Ocean currents	63	9	28	3.98	1.03	28	2.32	1.44	30
Properties of ocean water	52	12	35	3.84	1.18	35	2.11	1.28	36
Topography of the ocean floor	63	11	26	3.90	1.05	31	2.60	1.36	20
Tides	67	11	22	4.07	1.02	24	2.41	1.38	27
Waves	59	9	32	3.89	1.12	32	2.38	1.35	29
Earth/space science (or Earth science) content topics median rating				4.15			2.59		

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Physics									
Distance, displacement, speed, velocity, acceleration	100	0	0	4.91	0.33	2	3.71	1.45	2
Position-time graphs and velocity-time graphs	98	1	1	4.51	0.77	17	3.15	1.37	12
Newton's laws of motion	99	1	0	4.95	0.27	1	3.52	1.62	5
Static forces	94	1	5	4.38	0.81	20	2.98	1.47	20
Law of gravitation	94	1	5	4.37	0.83	21	2.92	1.52	21
Kepler's laws	56	5	39	3.40	1.22	52	2.06	1.18	51
Free fall motion	100	0	0	4.75	0.54	8	3.37	1.52	6
Projectile motion	99	0	1	4.59	0.70	14	3.06	1.52	17
Uniform circular motion: centripetal acceleration	94	0	6	4.39	0.79	19	2.92	1.50	21
Simple harmonic motion	82	0	18	3.98	1.03	36	2.67	1.49	31
Momentum and conservation of momentum	99	0	1	4.71	0.61	9	3.15	1.62	12
Kinetic energy and potential energy	99	1	0	4.82	0.47	4	3.36	1.62	7
Work and the work-energy theorem	97	0	2	4.60	0.66	12	3.15	1.63	12
Torque and rotational motion	68	0	31	3.74	1.03	44	2.66	1.53	33
Temperature scales	49	37	13	3.79	1.00	42	2.91	1.47	23
Specific heat and calorimetry	48	32	19	4.04	0.95	35	2.56	1.47	37
Heat transfer: conduction, convection, radiation	46	32	21	3.97	0.87	38	2.57	1.39	36
Thermal expansion	48	19	32	3.73	1.01	45	2.31	1.28	43
Latent heat and phases of matter: solid, liquid, gas	48	33	18	4.05	0.91	33	2.55	1.42	38
Ideal gas law	31	47	21	3.92	0.98	39	2.60	1.47	35
Kinetic theory of gases	34	42	23	3.84	1.01	41	2.30	1.37	44
Laws of thermodynamics	46	22	30	3.97	0.96	37	2.51	1.50	40
Production of waves: acceleration of charges and vibration	81	2	17	4.12	1.04	31	2.40	1.34	41
Properties of waves: wavelength, frequency, speed, amplitude	90	4	6	4.65	0.68	10	3.18	1.61	9
Electromagnetic spectrum	83	9	8	4.32	0.91	23	2.91	1.46	23
Interaction of light with matter: reflection, refraction, absorption, emission	87	2	11	4.43	0.77	18	2.80	1.45	28
Doppler effect	87	4	9	4.13	0.94	29	2.39	1.25	42
Diffraction and interference	79	3	18	4.12	0.97	30	2.64	1.53	34
Images formed by mirrors and/or lenses	73	4	23	4.20	0.96	28	2.83	1.55	27
Optical instruments: microscopes and/or telescopes	40	8	51	3.27	1.13	54	2.25	1.22	45
Lasers and holography	29	5	67	2.99	1.13	57	1.83	1.02	57
Electrostatics: Coulomb's law	82	1	16	4.60	0.72	13	3.18	1.67	9
Electric field	79	2	19	4.31	0.84	26	3.00	1.68	18
Electric potential and potential difference	80	1	19	4.55	0.70	15	2.99	1.66	19

Table 4.7

Science Curriculum Survey Results: Percent Taught, Mean Rating, and Rank for Each Content Topic, by Respondent Group *(continued)*

	High school						College		
Content topic	% Taught	% Taught prior	% Not taught	Mean rating	SD	Rank	Mean rating	SD	Rank
Current, resistance, voltage; Ohm's law	84	1	15	4.78	0.57	7	3.09	1.64	16
Conductivity: conductors and insulators	78	3	18	4.31	0.86	24	2.80	1.47	28
Capacitance and capacitors	54	1	45	3.88	1.07	40	2.55	1.50	38
DC circuits	82	2	16	4.51	0.77	16	2.87	1.53	25
AC circuits	36	4	60	3.68	1.24	47	2.19	1.35	46
Electrical energy and power	79	1	19	4.35	0.83	22	2.84	1.52	26
Magnetism and magnetic effects of current	70	3	27	4.25	0.96	27	2.79	1.53	30
Electromagnetic induction	58	2	39	4.05	0.97	32	2.67	1.57	31
Atomic structure: protons, neutrons, electrons	34	52	14	4.31	0.94	25	3.18	1.57	9
Density	34	52	14	4.05	0.99	34	3.15	1.45	12
Deformation of solids	18	23	60	3.02	1.20	56	1.93	1.08	56
Fluid behavior: hydrostatics and/or hydrodynamics	35	15	50	3.54	1.16	50	2.12	1.29	50
Nuclear decay: radioactivity	33	22	45	3.72	1.02	46	2.15	1.34	49
Nuclear reactions: fission and/or fusion	34	21	45	3.66	1.05	48	2.02	1.30	53
Wave-particle duality	52	5	43	3.76	1.09	43	2.18	1.44	47
Uncertainty principle	26	11	62	3.39	1.09	53	2.05	1.37	52
Quantum physics: atomic spectra	32	14	53	3.63	1.05	49	2.16	1.42	48
Pauli exclusion principle and the periodic table	12	27	60	3.09	1.06	55	1.97	1.32	55
Relativity (general and/or special)	36	2	61	3.44	1.03	51	1.99	1.33	54
Units of measurement; metric system	82	17	1	4.83	0.55	3	4.12	1.19	1
Vectors	95	1	3	4.79	0.53	6	3.68	1.46	3
Conversion of energy from one form to another form	95	5	1	4.62	0.70	11	3.32	1.56	8
Conservation of energy	98	2	0	4.80	0.47	5	3.54	1.60	4
Physics content topics median rating				4.13			2.80		