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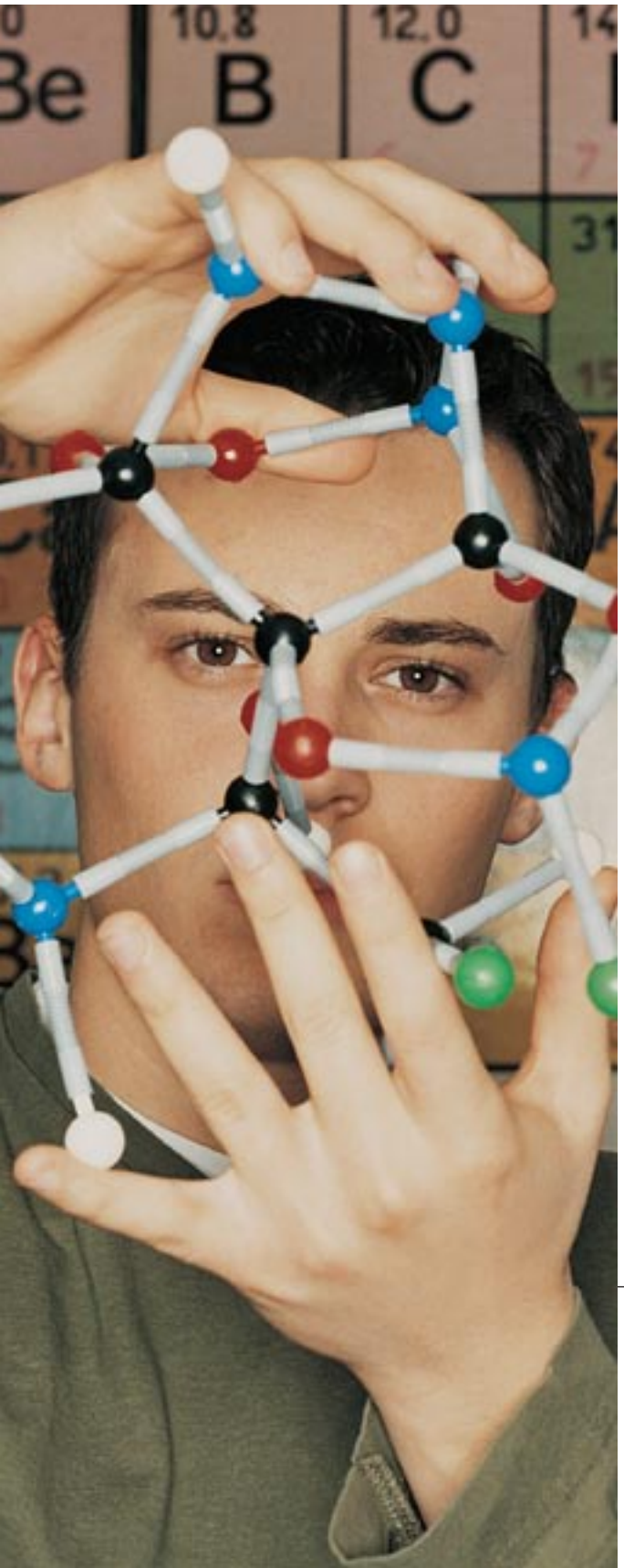

Aligning science assessment standards: Oklahoma and the 2009 National Assessment of Educational Progress (NAEP)

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July 2007

Prepared by

Michael Timms
WestEd

Steven Schneider
WestEd

Cindy Lee
WestEd

Eric Rolfhus
REL Southwest

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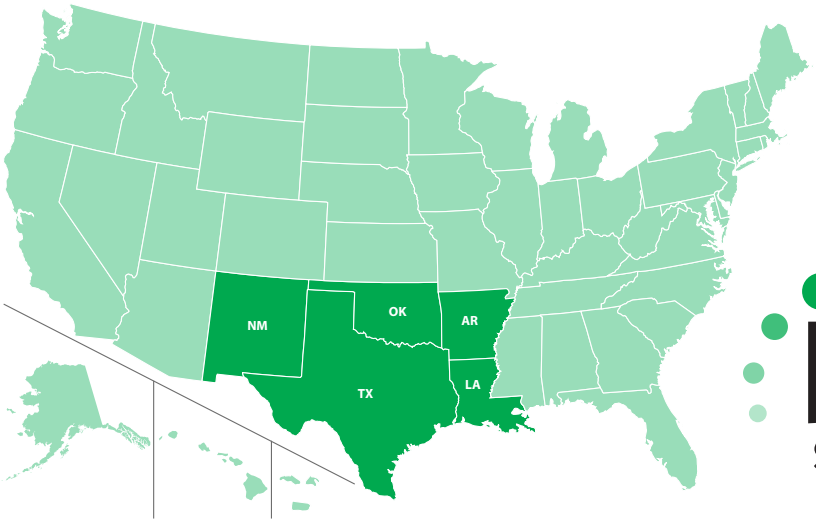

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July 2007

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This report is available on the regional educational laboratory web site at http://ies.ed.gov/ncee/edlabs.

Summary

Aligning science assessment standards: Oklahoma and the 2009 National Assessment of Educational Progress (NAEP)

This policy research document is intended for Oklahoma policymakers to use when examining possible changes to the state assessment's alignment with the National Assessment of Educational Progress (NAEP). The 2009 NAEP test is not yet in existence, so the purpose of this report is to give policymakers a head-start in determining where they might, if they so decide, begin to make changes in their assessment standards and specifications to develop an assessment system more closely aligned with that used for the NAEP.

Reviewers found Oklahoma to be generally unaligned with the NAEP. Oklahoma's standards, on the whole, are less detailed and contain less content than the NAEP. The majority of the NAEP content statements are unaddressed by the content standards and objectives in Oklahoma's test specifications documents. In grade 4, 82 percent of the NAEP content statements are unaddressed by Oklahoma, in grade 8, 53 percent of the NAEP content statements are unaddressed, and in NAEP grade 12, 80 percent of the NAEP content statements are unaddressed. In addition, in all three comparisons, Oklahoma has only about 25 percent of the number of standards in the NAEP. Standards in the Oklahoma test specifications documents are simpler and more general than those of the NAEP.

The average alignment rating for Oklahoma at grade 5 and the NAEP at grade 4 is 1.24, indicating a general nonalignment between Oklahoma and the NAEP. (A rating of 1 indicates no alignment and a rating of 3, full alignment.) At grade 8, the alignment rating is 1.53, indicating a level of alignment between nonalignment and partial alignment. At grade 12, the average alignment rating is 1.24, because the NAEP's physical science and Earth and space science content areas are unaddressed by Oklahoma's biology standards. The overall alignment rating for the NAEP life science portion only was found to be 1.92, indicating partial alignment when physical science and Earth and space science are excluded.

This report reveals current alignment issues between the state's tests and the future NAEP tests and may be especially important to policymakers considering revising science standards and assessments in line with No Child Left Behind requirements for state science tests in elementary, middle, and high schools. If state policymakers wish to increase the alignment between the state assessments and the NAEP, areas to consider are adding physical science and Earth and space science to the high school examination and including a wider variety of test item types. Revising assessments requires considerable time and

resources, so policymakers must carefully consider their capacity to make changes and the degree to which such changes will benefit students.

Grade 4 alignment

Almost all NAEP content is unaddressed by Oklahoma's objectives in its test specifications document.

Reviewers found Oklahoma's standards to be far more general than those in the NAEP. The NAEP contains 33 content statements, 15 in physical science, 7 in life science, and 11 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 8 content-laden standards (excluding process and inquiry standards), with 3 objectives in physical science, 2 in life science, and 3 in Earth and space science. In addition, 82 percent of the NAEP content in grade 4 is unaddressed by Oklahoma's objectives in the grade 5 test specifications document.

Reviewers noted that although the Oklahoma objectives are more general than those in the NAEP, the test specifications document is well organized. They also noted that the document appears to describe the parameters of the test more than the actual content standards.

It is possible that greater alignment would have been found if this review committee had also used the Oklahoma Priority Academic Student Skills standards for grade levels below grade 5. However, because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this study.

The majority of NAEP content statements are unaddressed by Oklahoma's content objectives, and the overall alignment rating for Oklahoma science content at grade 5 and the NAEP grade 4 is 1.24.

Grade 8 alignment

More than half of the grade 8 NAEP content is unaddressed by Oklahoma's objectives in its grade 8 test specifications document.

Reviewers found Oklahoma's standards to be far more general than those in the NAEP. The NAEP contains 43 content statements for grade 8, 16 in physical science, 8 in life science, and 15 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 11 content-laden standards (excluding process and inquiry standards), with 4 objectives in physical science, 2 in life science, and 5 in Earth and space science. In addition, 53 percent of the NAEP content in grade 8 is unaddressed by Oklahoma's objectives in the grade 8 test specifications document.

Reviewers noted that Oklahoma's science processes and inquiry standards are thorough and well articulated, but the content standards, which were the focus of this review, are not sufficiently broken down into detailed components. Reviewers also noted that although the Oklahoma objectives are much more general than those in the NAEP, the standards are well organized.

Because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this study.

This alignment study found the majority of NAEP content statements to be unaddressed by Oklahoma's content objectives, and the overall alignment rating is 1.53, indicating a level of alignment between nonalignment and partial alignment.

Grade 12 alignment

The majority of the grade 12 NAEP content is unaddressed by Oklahoma's objectives in its biology test specifications document.

Reviewers found Oklahoma's standards to be far more general than those in the NAEP. The NAEP contains 49 content statements for grade 12: 23 in physical science, 13 in life science, and 13 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 13 content-laden standards (excluding process and inquiry standards), all in life science. Additionally, 80 percent of the NAEP content in grade 12 is unaddressed by Oklahoma's objectives in the biology test specifications document.

Reviewers noted that Oklahoma's science processes and inquiry standards constitute more than half of the biology standards. Reviewers also noted that although the Oklahoma objectives are much more general than those in the NAEP, the standards are well organized.

Because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this study, although the Oklahoma document covers only biology.

This alignment study found the majority of NAEP content statements to be unaddressed by Oklahoma's content objectives, and the overall alignment rating for Oklahoma science content in biology and the NAEP grade 12 is 1.24, indicating nonalignment. However, the overall alignment rating between Oklahoma's biology test specifications standards and NAEP standards in life science is 1.92, indicating partial alignment. Thus, Oklahoma's end-of-instruction biology test specifications are partially aligned to the most comparable portion of the NAEP grade 12 content standards.

Test specifications

Reviewers commented that Oklahoma would do well to consider the scope of its standards alongside the standards of the NAEP and of other states to better understand the discrepancies in alignment. Reviewers at each of the three grade levels noted that despite the generality of Oklahoma's standards, the standards are well organized and the documents are easy to follow.

Standards and test specifications represent the starting point for the development of tests and test items. In the ideal alignment study state science assessments would be compared with NAEP assessments directly at the item level. At some future date the NAEP 2009 assessment items may be available for such a study.

Since the purpose of this report is to allow policymakers the opportunity to examine their alignment with NAEP before the test is implemented, no further research is suggested at this time.

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Tables

This policy research document is intended for policymakers to use when examining possible changes to the state assessment's alignment with the National Assessment of Educational Progress (NAEP).

BACKGROUND TO THE STUDY

This report presents the findings of an alignment study comparing the new science framework for the 2009 NAEP and the accompanying science assessment and item specifications with the Oklahoma state science assessment. More details about the documents compared are in appendix A. The study was conducted for the Regional Education Laboratory Southwest, funded by the Institute of Education Sciences to provide research and support to Arkansas, Louisiana, New Mexico, Oklahoma, and Texas. The study was undertaken in anticipation of a growing need in the region to be better informed about how state assessment standards in science compare with those tested in the NAEP.

The 2009 NAEP test is not yet in existence, so the purpose of this report is to give policymakers a headstart in determining where they might, if they so decide, begin to make changes in their assessment standards and specifications to develop an assessment system more closely aligned with that used for the NAEP.

Five factors make this study timely. First, the importance of state science assessments has been increased by the No Child Left Behind Act of 2001. Beginning in the 2007/08 school year, states are required to administer science assessments to all students in each of the elementary, middle, and high school levels, holding states and local school districts accountable for student academic achievement in science (NCLB, 2001).

Second, the NAEP is increasingly being used as a benchmark against which student achievement across the nation can be compared (Linn, 2005; Linn, Baker, & Herman, 2005). The NAEP has been dubbed the "nation's report card," and when fresh NAEP results are released—as they were for science in 2006, following an administration of the test in 2005—the media report the results (Cavanagh, 2006a, 2006b). Although states are not sanctioned for failing to demonstrate NAEP student performance improvement, NAEP data do provide an external accountability benchmark and serve to verify student achievement on state assessments. In fact, the National Center for Education Statistics has a website (http://nces.ed.gov/nationsreportcard/nde/statecomp/) that allows anyone to create customized comparative reports based on the latest NAEP data. So anyone can create tables that compare states and jurisdictions based on the average scale scores for selected groups of public school students within a single assessment year, or compare the change in performance between two assessment years.

Third, NAEP data are being used more in education research to investigate how the No Child Left Behind provisions have played out in different states. For example, Olson (2005) compared the percentages of students at or above the proficient

level on the 2005 state grade 8 mathematics assessments in 33 states. The study showed that, on average, 33 percent more students scored at or above the proficient level according to the state assessments than did so according to the NAEP. As yet, no similar study has been done of science, but with the release of the 2005 NAEP results it is now possible to do so.

Fourth, political attention is beginning to focus on using the NAEP as a yardstick for measuring state standards (Olson, 2007). In January 2007 two bills were introduced in Congress, one seeking to encourage states to benchmark their own standards and tests to the NAEP and another calling for states to adopt voluntary "American education content standards" in mathematics and science that would be developed by the National Assessment Governing Board, the body responsible for the NAEP. These issues will doubtless be topics of debate in the upcoming reauthorization of the No Child Left Behind Act.

Fifth, the standards and test specifications that form the blueprint for the content the NAEP science assessment covers and the types of items it uses were revised in 2006. The 2009 NAEP framework takes account of the latest knowledge on science learning and assessment, which suggests that measuring student understanding involves much more than assessing factual knowledge. It defines the science knowledge and skills that science-literate students should possess at grades 4, 8, and 12. The assessment itself, while retaining some familiar paper-and-pencil assessment formats, will also include student performance assessments in both classroom settings and computer simulations. The 2009 NAEP framework will determine the shape of NAEP science assessments through 2017, setting the direction of science assessment across the nation.

Several factors are working together to raise the National Assessment of Educational Progress to a de facto national benchmark, and states want to know how well their state standards align with it

These factors are working together to gradually raise the NAEP to a de facto national benchmark, and states naturally want to know how well their state standards align with the NAEP so they can make informed decisions about possible changes to their own standards and assessment systems. This report describes the results of a systematic alignment study of science assessment standards conducted for that purpose. Details of the study are in appendix B.

The intent of this report is to inform those in the Oklahoma State Department of Education who are responsible for shaping the state assessment in science how the current assessment standards and test specifications compare with those of the NAEP 2009 assessment.

Similar reports have been completed for Arkansas, Louisiana, New Mexico, and Texas, but there is no intent to compare Oklahoma with these other states. This report shows where there is good content alignment with NAEP standards, identifies where there is partial alignment, pinpoints NAEP standards where there are no corresponding state standards, and highlights where the Oklahoma standards go beyond the NAEP. It also deals with the assessment specifications, showing what percentages of the NAEP assessment at each grade level are devoted to different science topics and comparing that with the coverage of the topics in the Oklahoma assessment. And it compares the proportions of types of items used to test students' science knowledge and skills. Through comprehensive comparative analysis, the report provides a way for the Oklahoma Department of Education to gauge how well its tests are doing in covering the depth of science understanding expected on the NAEP.

The results are presented in the summary tables and narratives in the sections that follow. Those sections provide an analysis that highlights the differences between the NAEP's content and Oklahoma's content as presented by the test specifications documents in grades 4 and 8 and in end-of-instruction biology. For more detail about the alignment of the state content to the individual content statements of the NAEP, turn to the tables in appendices C–E. They show exactly which Oklahoma standards align with particular NAEP statements and, in cases of partial alignment, explain

why the alignment is incomplete. For a discussion of methodology, see box 1 and appendix B.

CONTENT ALIGNMENT AT GRADE 4

The NAEP grade 4 science standards were compared to the standards in the Oklahoma grade 5 test specifications document. Since the NAEP science standards used in this study are from the NAEP 2009 science assessment and item specifications document, the review committee found it appropriate to compare the NAEP science assessment and item specifications standards to the Oklahoma test specifications standards, although the NAEP assesses students in grade 4 and Oklahoma assesses its students in grade 5.

For grade 4, the NAEP provides 33 distinct content statements (displayed in parentheses in table 1). Two of these content statements (6 percent) are fully addressed by Oklahoma in the test specifications document, 4 (12 percent) are partially addressed, and 27 (82 percent) are unaddressed.

The average alignment rating for grade 4 is 1.24 (table 1). The majority of content statements were given ratings of 1, which means that state standards typically do not address NAEP content (figure 1 and appendix C).

Reviewers observed that NAEP standards cover more content in more detail than the Oklahoma standards in the test specifications document.

BOX 1

Methodology

The chief research questions driving this study were "To what extent do current state assessment standards cover the content on which NAEP 2009 assessments will be based?" and "To what extent do current state assessment specifications align with the NAEP 2009 assessment specifications?"

The methodology used to answer these questions followed the successful pattern of a similar study conducted by WestEd in New England, which examined the alignment of math and reading standards with the NAEP. The methodology developed by WestEd for the New England study was designed to include all the most prominent alignment methodologies, which are discussed in appendix B. Thus far, alignment studies and methods have focused on aligning standards and tests, whereas the objective of this study was to compare one set of assessment standards and specifications with another. The methodology in this study, however, is based on methods for aligning standards with tests, because similar principles are used in both types of alignments.

In this study reviewers followed the methodology of the portion of the previous study examining alignment between two sets of standards. Following the methodology of Achieve, test blueprints were examined to find correspondence between the two documents (see appendix B). Reviewers performed gap analyses to identify content included in one set of standards but not the other, identified issues of order so they could reveal differences in the grade levels at which standards appear, and examined the degree to which the standards and assessments cover content to the same depth and have similar cognitive demands (depth-of-knowledge consistency) and the degree to which assessments cover the same range of content as the corresponding standards (range-of-knowledge correspondence) to determine whether there was a match between the state and the NAEP in the level of detail, cognitive demands, and range of content covered. A coding scheme was used to indicate alignment issues and reviewer ratings, and a matrix-like format was created to facilitate alignment.

Reviewers attended several training sessions, conducted individual reviews, and then met in teams of two to reach consensus on ratings. This consensus method was designed to create one consensus rating per NAEP standard with the help of a moderator and was not intended to allow for disagreements. This methodology was determined to be best suited to the scope and timing of this study. The consensus methodology is designed to highlight areas for states to examine, not to gather large amounts of data, record multiple ratings, or measure interrater reliability.

TABLE 1

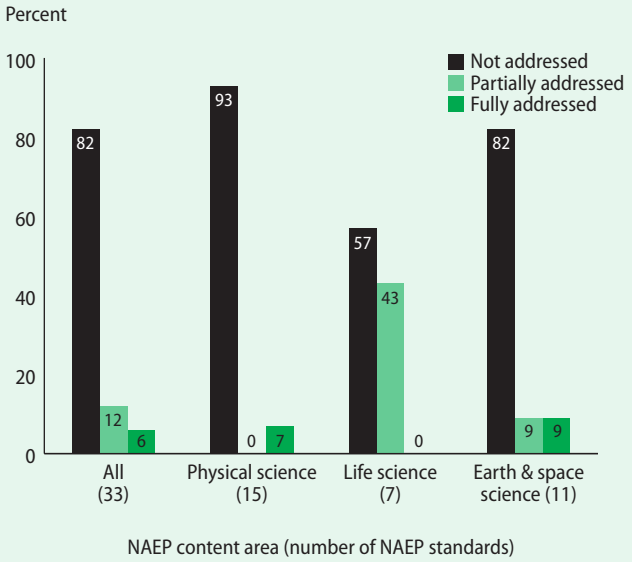
Average ratings of alignment of Oklahoma grade 5 test specifications objectives and National Assessment of Educational Progress grade 4 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (15)	1.13
Matter (6)	1.33
Energy (5)	1.00
Motion (4)	1.00
Overall life science (7)	1.43
Structures and functions of living systems (4)	1.75
Changes in living systems (3)	1.00
Overall Earth and space science (11)	1.27
Earth and space in time (3)	1.00
Earth structures (3)	1.33
Earth systems (5)	1.40
All content (33)	1.24

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

FIGURE 1

The majority of Oklahoma grade 5 standards do not address National Assessment of Educational Progress grade 4 content statements



Areas of full alignment

Two NAEP grade 4 content statements are fully addressed by Oklahoma test specifications standards. These statements are P4.1—measurable properties of objects and substances, and E4.8—changes in weather from day to day and over seasons.

Areas of partial alignment

Four NAEP grade 4 content statements have partial alignment with Oklahoma's standards in the Oklahoma test specifications document. These standards are L4.1—basic needs of organisms, L4.3 and L4.4—interdependence of organisms, and E4.4—natural Earth materials.

Raters found that many Oklahoma standards imply content that the NAEP addresses in depth. In addition, some NAEP standards were found to be more detailed or to contain more content than corresponding Oklahoma standards, resulting in partial alignment.

Areas of nonalignment

The majority of the NAEP's content statements (82 percent) could not be matched with the Oklahoma standards provided in the Oklahoma test specifications document. Overall, Oklahoma's content is not well aligned with the NAEP's content.

Areas where Oklahoma's benchmarks go beyond the NAEP content statements

Oklahoma has 24 objectives for grade 5. The NAEP does not address, in its content statements, 14 of the 16 science processes and inquiry objectives. All other objectives in Oklahoma are addressed by the NAEP.

The NAEP does not address the science processes and inquiry standards because the NAEP discusses inquiry in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

Summary of grade 4 alignment

Almost all NAEP content is unaddressed by Oklahoma's objectives in its test specifications document.

Reviewers found Oklahoma's standards to be far more general than those in the NAEP. The NAEP contains 33 content statements, 15 in physical science, 7 in life science, and 11 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 8 content-laden standards (excluding process and inquiry standards), 3 in physical science, 2 in life science, and 3 in Earth and space science. In addition, 82 percent of all NAEP content in grade 4 is unaddressed by the Oklahoma objectives in the grade 5 test specifications document.

Reviewers noted that although the Oklahoma objectives are much more general than those in the NAEP, the test specifications document as a whole (including its content standards) is well organized. Reviewers also noted that the document appeared to describe the parameters of the test more than the actual content standards.

It is possible that greater alignment might have been found if this review committee had also used the Oklahoma Priority Academic Student Skills standards for grade levels before grade 5. However, because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this study.

The majority of NAEP content statements are unaddressed by Oklahoma's content objectives, and the overall alignment rating for Oklahoma science content at grade 5 and the NAEP grade 4 is 1.24.

CONTENT ALIGNMENT AT GRADE 8

The NAEP grade 8 science standards were compared with the objectives in the Oklahoma grade 8 test specifications document. Since the NAEP science standards used in this study are in the NAEP 2009 science assessment and item specifications document, the review committee found it appropriate to compare the NAEP science assessment and item specifications standards with the Oklahoma test specifications standards.

The majority of NAEP content statements for grade 4 are unaddressed by Oklahoma's content objectives for grade 5

For grade 8 the NAEP provides 43 distinct content statements (displayed in parentheses in table 2). Three (7 percent) are fully addressed by Oklahoma benchmarks, 17 (40 percent) are partially addressed, and twenty-three (53 percent) are unaddressed.

The average alignment rating for grade 8 is 1.53. The majority of content statements were given ratings of 1, which indicates that state standards typically do not address NAEP content (figure 2 and appendix D).

Areas of full alignment

Three NAEP grade 8 content statements are fully addressed by the Oklahoma grade 8 assessment standards. The NAEP content statements with which Oklahoma is fully aligned are P8.14—speed and motion of an object, L8.12—similarities among organisms and classification, and E8.3—fossils.

Areas of partial alignment

Forty percent of the NAEP content statements are partially addressed by Oklahoma content in the test specifications document.

Much of the reason that the Oklahoma standards were rated as partially addressing the content in the NAEP is that the NAEP content statements are often more detailed and contain more content than the Oklahoma statements. For example, P8.5 deals with substances and their classifications according to physical and chemical properties. Oklahoma's matching standard (5-PS-1.1) states that matter has physical properties used for identification.

TABLE 2

Average ratings of alignment of Oklahoma grade 8 test specification objectives and National Assessment of Educational Progress grade 8 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (16)	1.63
Matter (7)	1.57
Energy (6)	1.50
Motion (3)	2.00
Overall life science (12)	1.38
Structures and functions of living systems (8)	1.38
Changes in living systems (4)	1.75
Overall Earth and space science (15)	1.47
Earth and space in time (4)	2.00
Earth structures (6)	1.33
Earth systems (5)	1.20
All content (43)	1.53

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

However, NAEP's standard also details classes of substances, such as metals and acids, while Oklahoma does not provide such detailed examples. Another example is the alignment between the NAEP's L8.11 and Oklahoma's 8-LS-3.2. The NAEP contains content with regard to organisms' traits that allow for survival, including a statement regarding the fossil evidence for extinction of species. The corresponding Oklahoma objective does not mention extinction or fossils.

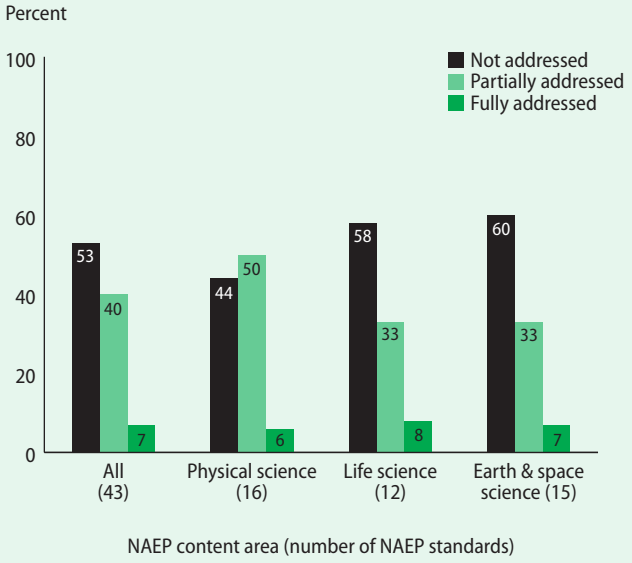
Areas of nonalignment

Twenty-three of the 43 NAEP content items are not addressed by any of the Oklahoma content statements in the grade 8 test specifications document.

The majority of the NAEP's content statements (53 percent) could not be matched with the Oklahoma standards provided in the Oklahoma test specifications document. Overall, Oklahoma's content is not well aligned with NAEP's content.

FIGURE 2

The majority of Oklahoma grade 8 standards do not address National Assessment of Educational Progress content statements



Areas where Oklahoma benchmarks go beyond the NAEP content statements

The NAEP content statements do not address 19 of the 20 Oklahoma statements in science processes and inquiry or 2 of the 5 Oklahoma objectives in Earth and space science.

The NAEP does not address the science processes and inquiry standards because it discusses inquiry in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

Summary of grade 8 alignment

More than half of the grade 8 NAEP content is unaddressed by Oklahoma's objectives in its grade 8 test specifications document.

Reviewers found Oklahoma's standards to be far more general than those in the NAEP. The grade 8 NAEP contains 43 content statements, 16 in physical science, 8 in life science, and 15 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 11 content-

laden standards (excluding process and inquiry standards), with 4 objectives in physical science, 2 in life science, and 5 in Earth and space science. In addition, 53 percent of all NAEP content in grade 8 is unaddressed by Oklahoma's objectives in the grade 8 test specifications document.

Reviewers noted that Oklahoma's science processes and inquiry standards are thorough and well articulated, but the content standards, which were the focus of this review, are not sufficiently broken down into detailed components. Reviewers also noted that although the Oklahoma objectives are much more general than those in the NAEP, the standards are well organized.

Because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this alignment. This alignment study found the majority of NAEP content statements to be unaddressed by Oklahoma's content objectives, and the overall alignment rating is 1.53, indicating a level of alignment between nonalignment and partial alignment.

CONTENT ALIGNMENT AT GRADE 12

The NAEP grade 12 science standards were compared with the Oklahoma end-of-instruction biology standards in the test specifications document. Because Oklahoma assesses its high school students in science using only end-of-instruction biology standards, the end-of-instruction test specifications document was found to be the most comparable document to the NAEP's grade 12 test specifications. Since Oklahoma's high school assessment covers only biology, while the NAEP covers life science, physical science, and Earth and space science, a low level of alignment was expected.

For grade 12, the NAEP provides 49 distinct content statements (displayed in parentheses in table 3). Two (4 percent) are fully addressed by Oklahoma benchmarks, 8 (16 percent) are partially addressed, and 39 (80 percent) are not addressed.

More than half of the grade 8 NAEP content is unaddressed by Oklahoma's objectives

The average alignment rating for grade 12 is 1.24. The majority of content statements were given ratings of 1, which means that most state standards do not address NAEP content (figure 3 and appendix E).

Areas of full alignment

Two of the 49 NAEP grade 12 content statements are fully addressed by Oklahoma content objectives in the test specifications document. The two fully-addressed standards are L12.5—matter and energy passing through food webs and ecosystems, and L12.10—sorting and recombination of genes in sexual reproduction.

Areas of partial alignment

Eight of the NAEP grade 12 content statements (16 percent) have partial alignment with the standards in Oklahoma's end-of-instruction biology test specifications. Oklahoma benchmarks often imply content explicitly stated by the NAEP, and the NAEP content statements often contain more content than Oklahoma's objectives.

The 8 NAEP content statements with which there is partial alignment are L12.3—the regulation of cellular processes, L12.4—photosynthesis, L12.6—recombination of chemical elements, L12.7—the changing of ecosystems, L12.8—genes and hereditary information, L12.9—genetic information in DNA and altered genes, L12.12—molecular and anatomical evidence for evolution, and L12.13—evolution as the consequence of various factors.

If one examines only the alignment between Oklahoma's biology content in the test specifications document and NAEP life science, the overall alignment rating is 1.92, indicating partial alignment. Oklahoma's end-of-instruction biology test specifications are partially aligned with the most comparable portion of the NAEP grade 12 content standards.

TABLE 3

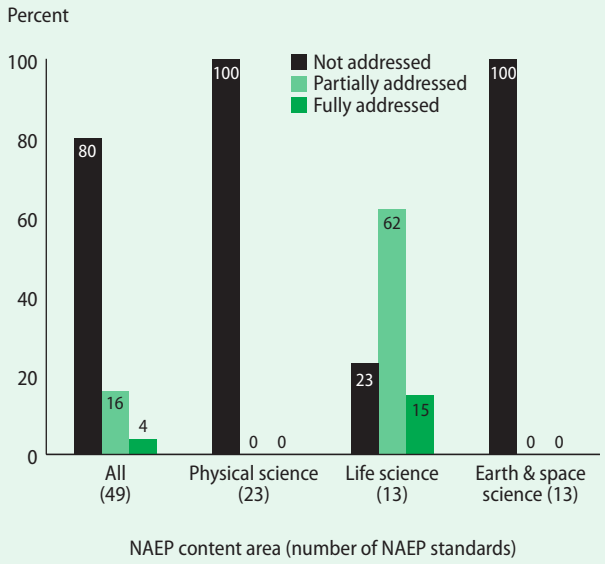
Average ratings of alignment of Oklahoma end-of-instruction biology test specifications objectives and National Assessment of Educational Progress grade 12 science content statements

NAEP content area (number of NAEP standards)	Average rating
Overall physical science (23)	1.00
Matter (7)	1.00
Energy (9)	1.00
Motion (7)	1.00
Overall life science (13)	1.92
Structures and functions of living systems (7)	1.86
Changes in living systems (6)	2.00
Overall Earth and space science (13)	1.00
Earth and space in time (7)	1.00
Earth structures (1)	1.00
Earth systems (5)	1.00
All content (49)	1.24

Note: Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that they partially address NAEP content statement, and 3 that they fully address or exceed NAEP content statement by targeted grade level.

FIGURE 3

The majority of Oklahoma end-of-instruction biology standards partially address National Assessment of Educational Progress content statements in life cience but do not address physical science or Earth and space science



Areas of nonalignment

The majority of the NAEP's content statements (80 percent) could not be matched with the Oklahoma standards provided in the Oklahoma test specifications document. Overall, Oklahoma's content is not well aligned with the NAEP's content.

The greatest areas of nonalignment are physical science and Earth and space science, because Oklahoma assesses its high school students on a statewide basis only in biology.

Areas where Oklahoma's benchmarks go beyond the NAEP content statements

The NAEP does not address 2 of the 13 content statements in Oklahoma's end-of-instruction biology test specifications document. In addition, the NAEP's content statements for grade 12 do not cover the 25 process and inquiry standards and objectives in Oklahoma's test specifications.

The NAEP does not address in its content statements Oklahoma's process and inquiry standards because it discusses inquiry in a section separate from the content statements, called "science practices," intended to crosscut all NAEP content.

Summary of grade 12 alignment

The majority of grade 12 NAEP content is unaddressed by Oklahoma's objectives in its biology test specifications document.

Reviewers found Oklahoma's standards to be far more general than those of the NAEP. The NAEP contains 49 content statements for grade 12, 23 in physical science, 13 in life science, and 13 in Earth and space science. In contrast, Oklahoma's test specifications document contains only 13 content-laden standards (excluding process and inquiry standards), all of which are in life science. Additionally, 80 percent of the NAEP content for grade 12 is unaddressed by Oklahoma's objectives in the biology test specifications document.

Reviewers noted that Oklahoma's science processes and inquiry standards compose more than half of the biology standards. Reviewers also noted that although the Oklahoma objectives are much more general than those of the NAEP, the standards are well organized.

Because the NAEP is itself a test specifications document, the review committee thought it most appropriate to use the Oklahoma test specifications document for this study, although the Oklahoma document covers only biology. This alignment study found the majority of NAEP content statements to be unaddressed by Oklahoma's content objectives, and the overall alignment rating for Oklahoma science content in biology and NAEP grade 12 is 1.24, indicating nonalignment. However, the overall alignment rating between Oklahoma's biology test specifications standards and NAEP life science standards is 1.92, indicating partial alignment. Thus, Oklahoma's end-of-instruction biology test specifications document is partially aligned to the most comparable portion of the NAEP grade 12 content standards.

TEST SPECIFICATIONS ALIGNMENT

The assessment specifications alignment involved two parts: examining the types of items found in the NAEP and in Oklahoma, and comparing the NAEP's and Oklahoma's distribution of items between the different science strands.

Science is a discipline with a strong tradition of investigation, experimentation, and application of knowledge and skills. Before the 2005 assessment, NAEP science assessments consisted primarily of short-answer, paper-and-pencil questions that were mostly multiple-choice, which can only go so far in assessing skills. To improve the assessment of the range of science knowledge and skills, the last two NAEP science frameworks have expanded the range of item types on the test. In particular, the 2009 NAEP framework takes advantage of advances in educational measurement and the development of computer-based assessments.

The majority of grade 12 NAEP content is unaddressed by Oklahoma's objectives in its biology test specifications document

Due to the varying ways that differing item types assess and reveal what students know and can do, the NAEP 2009 assessment specifications require future NAEP tests to incorporate a range of item types, allowing students to reveal their understanding in ways beyond traditional multiple-choice methods. Multiple-choice items, short constructed-response items, extended constructed-response items, hands-on performance tasks, and interactive computer tasks will all be used to more accurately assess student knowledge, thinking, and skills.

Each type of assessment item demands a unique response from students (selecting a response from a set of alternatives, writing an explanation or justification, or performing a virtual lab experiment). Individual items may draw on different types of stimuli (verbal, graphic, manipulative) to access the knowledge and skills required and may be scored in a variety of ways (right/wrong, partial credit, human scorers, computer software). By using several types of items the 2009 NAEP science assessment will require students to draw on multiple types of knowledge and a variety of skills for using and expressing that knowledge, thereby giving a more accurate picture of the breadth and depth of their learning. In this study, the following item types from the NAEP were compared with the types in use by the states.

In multiple-choice items, students reflect on the material and then select an answer from a limited number of alternatives. Well constructed multiple-choice items can probe important facts, broad concepts, and themes of science, as well as deductive reasoning skills.

Constructed-response items, in which students answer without reference to a provided list of alternatives, include short constructed-response items and extended constructed-response items. Constructed-response items can provide insight

By using several types of items the 2009 NAEP science assessment will require students to draw on multiple types of knowledge and a variety of skills for using and expressing that knowledge

into students' levels of conceptual understanding and assess their ability to communicate about science. They can also be used to probe students' ability to generate information related to science content statements and their interconnections (how two or more cyclic events are related). Constructed-response items may be particularly useful for probing the practices of using scientific inquiry or using technological design (interpret given data or provide a solution to a real-world problem).

In hands-on performance tasks, students manipulate selected physical objects and try to solve a scientific problem involving the objects. These exercises, if carefully designed, can probe student ability to combine science knowledge with the investigative skills reflective of the nature of science and inquiry.

Interactive computer tasks in the 2009 NAEP science assessment may involve information search and analysis, empirical investigation, simulation, or concept mapping. The broad purpose of interactive computer tasks in this context is to tap performance expectations that are more advantageously assessed in a virtual format, such as scientific modeling of microscopic or temporal phenomena, repeated experiments, or simulations of hazardous or messy lab situations. Interactive computer tasks are intended as a complement to the hands-on performance tasks, not as a replacement.

The NAEP specifications also include two other types of items, item clusters and predict-observe-explain item sets. Item clusters are groups of related items that provide more in-depth analysis of student performance than would a collection of discrete, unrelated items. They can be particularly useful in exploring student conceptions, predictions, or explanations of the natural world. The predict-observe-explain item sets (White & Gunstone, 1992) describe a situation and ask the student to predict, observe, or explain the outcome, sometimes with additional supporting detail. Predict-observe-explain items may involve using science principles or the cognitive demand of "knowing why (schematic knowledge)." Because these are really ways of clustering items and are not usually included in state test specifications, they were not used for comparison in this study.

Table 4 shows the percentages of various item types found in the NAEP and in Oklahoma. The NAEP will have 50 percent of student response time allocated to multiple-choice items and 50 percent to constructed-response items (short and extended). The current Oklahoma tests contain 100 percent multiple-choice items. Oklahoma does not have its item distributions proportioned by student response time, as does the NAEP, so the table shows the NAEP's proportions of student response times and Oklahoma's proportions of items, with

TABLE 4
Proportions of different item types on the Oklahoma science assessment

	NAEP	Oklahoma		
NAEP item types	All grades	Grade 5	Grade 8	End-of instruction biology
Multiple-choice items	50 percent	100 percent (86)	100 percent (86)	100 percent (116)
Constructed-response items (short and extended)	50 percent			
Hands-on performance tasks[a]	(≥1)			
Interactive computer tasks[a]	(≥1)			

a. Hands-on performance tasks and interactive computer tasks are combination items and can be categorized as multiple-choice or constructed-response.

the numbers of items in parentheses. In grades 5 and 8 there are 86 multiple-choice items, 45 assessing process and inquiry objectives and 41 assessing content standards (physical, life, and Earth and space sciences). In end-of-instruction biology there are 116 items, 60 assessing process and inquiry objectives and 56 assessing biology. There are no short constructed-response items, extended constructed-response items, hands-on performance tasks, or interactive computer tasks in the Oklahoma state assessments.

To consider how the state test coverage of the NAEP science topics matched, table 5 shows the proportions of testing time devoted to each of the three content areas for the NAEP and for the Oklahoma test. The first column of the table lists all the science topics included on the Oklahoma test. The first three topics (physical, life, and Earth and space sciences) are those covered in the NAEP, while the topic below those, process standards, is not separately assessed on the NAEP.

Under the column heading for elementary school, three subcolumns are shown. The first shows the proportion of testing time devoted to each topic by the NAEP. The second shows the proportion of items devoted to each topic by Oklahoma at grade 5. The third shows the difference between these proportions, a positive number if the Oklahoma test devotes more and a negative number if the NAEP devotes more. This pattern of columns is repeated for middle and high school. For the purposes of this comparison, the NAEP grade 12 was compared to Oklahoma's end-of-instruction high school test in biology. Because Oklahoma does not report its test proportions by student response time, as does the NAEP, the Oklahoma percentages are the proportions of numbers of items.

TABLE 5

Proportions of testing time allocated to different science topics on the National Assessment of Educational Progress and the Oklahoma science assessment (percent)

	Elementary school			Middle school			High school		
Content area	NAEP grade 4	Oklahoma grade 5	Difference	NAEP grade 8	Oklahoma grade 8	Difference	NAEP grade 12	Oklahoma end-of-instruction biology	Difference
Physical science	33	21	–12	30	19	–11	38	0	–38
Life science	33	14	–19	30	10	–20	38	48	+10
Science as inquiry	33	13	–20	40	19	–21	25	0	–25
Science and society	0	52		0	52		0	52	

TABLE 6

Comparison of the proportions of testing time allocated to only the National Assessment of Educational Progress science topics (percent)

	Elementary school			Middle school			High school		
Content area	NAEP grade 4	Oklahoma grade 5	Difference	NAEP grade 8	Oklahoma grade 8	Difference	NAEP grade 12	Oklahoma end-of-instruction biology	Difference
Physical science	33	44	+11	30	39	+9	38	0	–38
Life science	33	29	–4	30	22	–8	38	100	+62
Earth and space science	33	27	–6	40	39	–1	25	0	–25

At all grade levels, the proportion of points Oklahoma devotes to each NAEP content strand is less than the proportion of time the NAEP devotes to each NAEP content strand. This is because Oklahoma allots a very large proportion of its test to assessing process standards, which are not a separate strand in the NAEP test specifications.

Table 6 ignores the amount of testing time devoted to process standards, which are not separately tested in the NAEP, and shows how the proportion of testing time in the NAEP, for the three NAEP strands, compares with the proportion of points in the state test. At the elementary and middle school levels, there are very slight differences in proportions when the process standards are excluded. In high school, there is a significant difference in proportion because the Oklahoma high school test assesses only biology, while the NAEP test covers physical science, life science, and Earth and space science.

APPENDIX A
THE DOCUMENTS COMPARED

This alignment study used the science framework of the 2009 National Assessment of Educational Progress and the accompanying science assessment and item specifications as its baseline for comparison (National Assessment Governing Board, 2006). The two NAEP documents were developed by a steering and a planning committee made up of leaders in science, science education, general education, assessment, and various public constituencies. The documents went through public and committee review processes before finally being adopted and published in 2006 by the National Assessment Governing Board. The 2009 framework will guide the test development until approximately 2017.

NAEP assessments in science are administered across all states in the nation according to a statistical sampling plan and to some selected urban areas. The NAEP tests students at grades 4, 8, and 12 every four to five years and is intended to provide a snapshot of what students at those grades know and can do in science. In addition, the resulting data on student knowledge and performance have been accompanied by background information that allows analyses of student demographic and instructional factors related to achievement. The assessments have been designed to allow comparisons of student performance over time and among subgroups of students according to region, parental education, gender, and race/ethnicity.

The NAEP 2009 science assessment will include two separately timed, 25-minute sections of science items and extra 30-minute sections for hands-on performance tasks and interactive computer tasks, which will be given only to a subset of all students sampled. There will be multiple test booklet forms, and a matrix sampling design will be used so that students do not all receive the same items. Instead of detailing the number of test items that will fall in various categories, the NAEP outlines its distribution of items by "student response time" and stipulates that 50 percent of student response time will be used in answering multiple-choice items, and the other 50 percent in constructed-response items. Constructed-response items will include short constructed-response, extended constructed-response, and concept-mapping tasks. In addition, at least one of each of the following item types must be used at each grade level: item clusters, predict-observe-explain item sets, hands-on performance tasks, and interactive computer tasks. Table A1 shows the stipulated distribution of items for the NAEP 2009 as a percentage of student response time:

The NAEP science content used in this study is shown in detail in chapter two, "Science Content," which is extracted from the Science Assessment and Item Specifications for the 2009 NAEP (National Assessment Governing Board, 2006).

This comparison was performed between the NAEP 2009 science assessment and item specifications and the Oklahoma test specifications documents, which were retrieved from the Oklahoma State Department of Education website. The Oklahoma documents used in this review of content and structure are the Oklahoma School

TABLE A1
National Assessment of Educational Progress distribution of items and standards by content area and grade

	Grade 4		Grade 8		Grade 12	
Content area	Share of response time (percent)	Number of content standards	Share of response time (percent)	Number of content standards	Share of response time (percent)	Number of content standards
Physical	33.3	15	30.0	16	37.5	23
Life	33.3	7	30.0	12	37.5	13
Earth and space	33.3	11	40.0	15	25.0	13

Testing Program: Oklahoma Core Curriculum Tests—Test Specifications End-of-Instruction Biology (Oklahoma Department of Education, 2006a), the Oklahoma School Testing Program: Oklahoma Core Curriculum Tests—Test Specifications Science Grade 5 (Oklahoma Department of Education, 2006b), and the Oklahoma School Testing Program: Oklahoma Core Curriculum Tests—Test Specifications Science Grade 8 (Oklahoma Department of Education, 2006c). The NAEP is administered to students in grades 4, 8, and 12, while Oklahoma gives its statewide tests in grades 5 and 8 and in end-of-instruction biology. In comparing Oklahoma's test specifications with the NAEP, the Oklahoma benchmarks at grades 5 and 8 and in end-of-instruction biology were used, in an effort to use the Oklahoma standards most likely to appear on the assessments and to compare test specifications with test specifications.

The Oklahoma School Testing Program includes the Oklahoma Core Curriculum Tests, which are intended to measure the proficiency of Oklahoma students in mathematics, reading, science, social studies, and writing. The statewide science tests are given at grades 5 and 8 and in end-of-instruction biology. The science tests were developed to directly align with the Oklahoma Priority Academic Student Skills (PASS)—the state's content standards or "objectives." Most of the items on the science tests are created to assess both a process and inquiry objective and a content objective. Tables A2–A4 illustrate Oklahoma's distribution of items and objectives by science strand.

The NAEP grade 4 and grade 8 content statements were compared only with the Oklahoma objectives in its test and item specifications at grade 5, grade 8, and end-of-instruction biology. Since the NAEP is a test and item specifications document from which the NAEP test is developed, it was thought most appropriate to compare it to Oklahoma's test and item specifications document forming the basis of the state's tests, rather than to the larger body of objectives found in the Priority Academic Student Skills.

TABLE A2

Number of items and objectives by standard—Oklahoma grade 5

Standard	Number of items	Number of objectives
Process standards		
Observe and measure	10	2
Classify	10	2
Experiment	11	4
Interpret and communicate	14	4
Inquiry	0	4
Content standards		
Physical science	18	3
Life science	12	2
Earth and space science	11	3
Total	86	24

TABLE A3

Number of items and objectives by standard—Oklahoma grade 8

Standard	Number of items	Number of objectives
Process standards		
Observe and measure	8	3
Classify	8	2
Experiment	16	6
Interpret and communicate	13	5
Inquiry	0	4
Content standards		
Physical science	16	4
Life science	9	2
Earth and space science	16	5
Total	86	31

TABLE A4

Number of items and objectives by standard—Oklahoma end-of-instruction biology

Standard	Number of items	Number of objectives
Process standards		
Observe and measure	8	3
Classify	8	2
Experiment	16	5
Interpret and communicate	20	8
Model	8	3
Inquiry	0	4
Content standards		
Physical science	0	0
Life science	56	13
Earth and space science	0	0
Total	116	38

APPENDIX B
HOW THE STUDY WAS CONDUCTED

The chief research questions driving this study were these: "To what extent do current state assessment standards cover the content on which NAEP 2009 assessments will be based?" and "To what extent do current state assessment specifications align with the NAEP 2009 assessment specifications?"

The methodology used to answer these questions followed the successful pattern of a similar study conducted by WestEd in New England, which examined the alignment of math and reading standards with the NAEP. The methodology developed by WestEd for the New England study was designed to include all the most prominent alignment methodologies, discussed below. Thus far, alignment studies and methods have focused on aligning standards and tests, whereas the objective of this study was to compare one set of assessment standards and specifications with another. In this study, however, the methodology used is based upon methodologies for aligning standards with tests, because similar principles are used in both types of alignments.

Eight independent alignment methodologies are examined in *Imperfect Matches: The Alignment of Standards and Tests* (Rothman, 2003), which describes methodologies by Norman L. Webb, Karen K. Wixson, Andrew C. Porter, Achieve, the Buros Center for Testing, the American Association for the Advancement of Science's Project 2061, CRESST, and SRI International.

- Webb's method involves evaluating the degree to which consistent content categories or content strands are found between the standards and assessments (categorical concurrence), the degree to which the standards and assessments cover content to the same depth and have similar cognitive demands (depth-of-knowledge consistency), the degree to which assessments cover the same range of content as the corresponding standards (range-of-knowledge correspondence), and the degree to which the distribution of assessment items matches the distribution of content standards (balance of representation) (Webb, 1997, 1999).

- Wixson's method (Wixson et al., 2002) is a modified version of Webb's and includes range-of-knowledge correspondence, balance of representation, coverage (whether each objective is covered by at least one assessment item), depth-of-knowledge consistency, and the extent to which the philosophy underlying the assessment matches the philosophy of the standards (structure-of-knowledge comparability).

- Porter's method (Porter, 2002) involves a matrix with rows representing topics and columns representing categories of cognitive demand, in which reviewers record values to represent the level of alignment.

- Achieve's method (Achieve, 2003) involves examining test blueprints to see whether they adequately reflect the map of test items to standards. It also involves examining the quality of the match between an assessment item and its corresponding standard (content centrality), the degree to which an item appropriately assesses the "performance" or cognitive demand presented by a standard (performance centrality), the degree to which the assessment's difficulty matches the difficulty presented by the standard (challenge), the degree to which the assessment's emphasis on content matches the standard's emphasis on content (balance) and the degree to which the assessment's breadth of content matches the standard's breadth of content (range).

- The Buros Center's methodology uses teachers to record four levels of alignment of items to standards (Impara, 2001).

- The Project 2061 methodology, developed by the American Association for the

Advancement of Science, includes independently rating materials and then meeting in two-person teams to reach a consensus that would be reconciled by Project 2061 staff (Stern & Ahlgren, 2002).

- The CRESST methodology includes identifying corresponding content topics, rating the centrality of the item to the topic, and rating the depth-of-knowledge level (Herman, Webb, & Zuniga, 2003).

- SRI International created codes for various portions of standards that were used to perform the alignment and to determine the degree of matching (Kreikemeier, Quellmalz, & Haydel, 2004).

The WestEd New England methodology was designed to include the major alignment methodologies. The developed methodology involved a "quality review" of grade level expectations within grades and across grades. Within grades a methodology was employed to account for depth of knowledge, breadth of knowledge, clarity, consistency, reasonableness, and assessability. Across grades, the study examined categorical concurrence, consistency, and assessability.

The study also involved an "alignment review" in which a methodology of examining gaps, order, depth, and breadth was used in order to compare the under-review grade level expectations with external referents. More specifically, the first step in the alignment review was to perform "gap analyses." Reviewers were to identify content in the grade level expectations that was absent in the external referent and content in the external referent absent in the grade level expectations. Reviewers then examined "order" to determine whether grade level expectations were included at the same grade level as matching content in the external referent. Last, reviewers examined "depth and breadth" to determine whether the content of the grade level expectations reflected the intended depth and breadth of the external referent. Because the alignment study in this report, which compares Oklahoma with the NAEP, focuses only on examining alignment between Oklahoma's assessment standards and specifications and the NAEP 2009 assessment standards and specifications, only part of WestEd's New England study methodology was used.

In this study, reviewers followed the methodology of the portion of the previous study examining alignment between two sets of standards. Test blueprints were examined to find correspondence between the two documents, which follows the methodology of Achieve. Reviewers performed gap analyses to identify content included in one set of standards but not the other, identified issues of order so they could reveal differences in the grade levels at which standards appear, and examined depth-of-knowledge and range-of-knowledge correspondence (following Webb's and Wixson's criteria) to determine whether there was a match between the state and the NAEP in the level of detail, cognitive demands, and range of content covered. A coding scheme (similar to that of the Buros Center) was used to indicate alignment issues and reviewer ratings, and a matrix-like format (similar to Porter's method) was created to facilitate alignment.

Reviewers attended several training sessions and then met in teams of two to reach consensus on ratings (similar to the Project 2061 method). This consensus method was designed to create one consensus rating per NAEP standard with the help of a moderator and was not intended to allow for disagreements. This methodology was determined to be best suited to the scope and timing of this study. The consensus methodology is designed to highlight areas for states to examine, not to gather large amounts of data, record multiple ratings, or measure inter-rater reliability.

The content reviews

State standards detail what students are expected to know and do, and as such they are a crucial area for examination. Assessment standards form the basis from which test items are conceived and developed, and they ultimately determine the content that

appears on tests. Therefore, this study compared state assessment standards to NAEP content statements through the completion of content reviews.

The content reviews were conducted by a team of six science educators under the leadership of a senior reviewer. The team was directed by Dr. Timms, who is a senior assessment researcher in the mathematics, science and technology program at WestEd and managing director of the Center for Assessment and Evaluation of Student Learning. The senior reviewer is a retired biology and AP biology teacher with 37 years of classroom experience, is a recipient of the Outstanding Biology Teacher Award for the state of California, and has worked in various teacher professional development capacities, including work with the Teacher Assessment Project and the National Board for Professional Teaching Standards.

The six science educators were chosen based on recommendations by the senior reviewer. The team was composed of individuals with science education experience ranging from serving on the National Board for Professional Teaching Standards' Science Committee and co-chairing the California Science Teachers Association Conference to being a technology instructor at a local university to developing widely used science curricula. All six reviewers are current, credentialed middle and high school science teachers. The reviewers have science teaching experience covering the full range of science content areas. Currently, four of the reviewers teach integrated science, one teaches Earth science, three teach biology, one teaches chemistry, and another is a middle school science teacher. The team was also supported by two research assistants.

To ensure that the review was systematic, WestEd developed a crosswalk instrument that was used to evaluate the alignment of the state assessment standards to the content standards contained in the new NAEP 2009 science framework. These crosswalk instruments contained NAEP standards at the appropriate grade level in the leftmost column, blank cells in the next column for reviewers to fill in corresponding state assessment standards, another column for providing ratings, a column for assigning codes, and a final column for various notes. Completed crosswalk instruments, or "alignment tables," can be found in appendixes C—E. An extract of a completed crosswalk instrument is shown, along with explanations, in figure B1.

Oklahoma's test objectives were given codes developed by WestEd to facilitate the ease of use of the documents. The coding scheme followed the pattern of grade level, strand, standard, objective. For example, the code "5-LS-2.2" indicates grade 5, life science, standard 2, and objective 2. The following codes were used to indicate the various strands:

SPI = Science processes and inquiry (for grades 5 and 8)
PI = Process and inquiry (for biology)
PS = Physical science
LS = Life science
ESS = Earth and space science

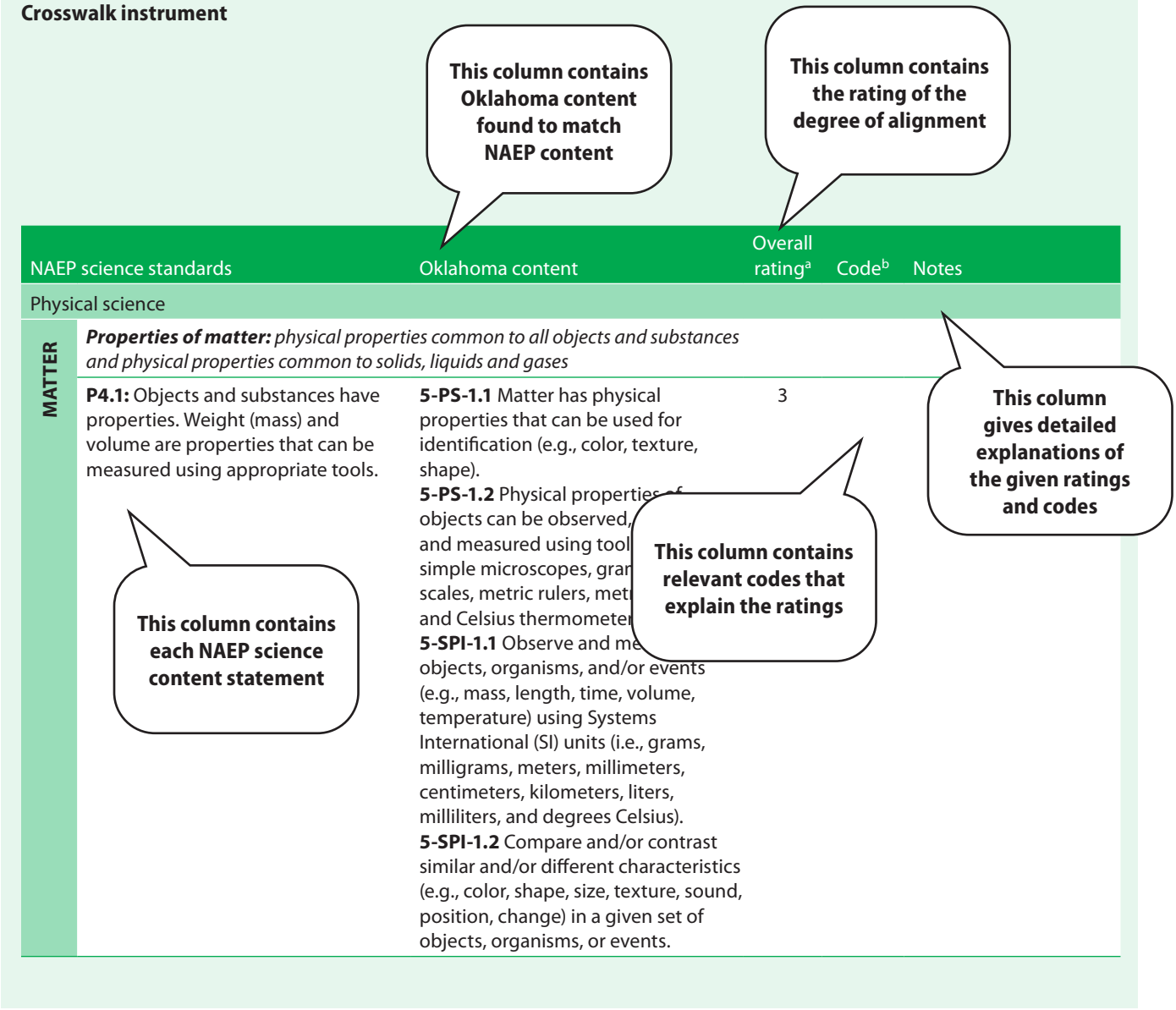
The rating scale used in the "overall rating" column of the crosswalk instrument was:

1—State standards do not address NAEP content statement
2—State standards partially address NAEP content statement
3—State standards fully address or exceed NAEP content statement by targeted grade level

When there was partial or nonalignment (ratings 2 or 1), the reviewers used a letter coding scheme to indicate the reason for the lack of alignment. The coding scheme was:

IC—Implied content	The content seems to be implied as part of the standard, but it is not explicitly stated.
LG—Content covered at a lower grade level	The NAEP standard is partially or fully covered at a lower state grade level.
HG—Content covered at a higher grade level	The NAEP standard is partially or fully covered at a higher state grade level.
MC—More content	The NAEP standard contains more content than do corresponding state standards.
MD—More detailed content	The NAEP standard contains content that is more detailed than corresponding state standards.

FIGURE B1
Crosswalk instrument



NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *physical properties common to all objects and substances and physical properties common to solids, liquids and gases*			
P4.1: Objects and substances have properties. Weight (mass) and volume are properties that can be measured using appropriate tools.	**5-PS-1.1** Matter has physical properties that can be used for identification (e.g., color, texture, shape). **5-PS-1.2** Physical properties of objects can be observed, and measured using tool simple microscopes, gra scales, metric rulers, met and Celsius thermometer **5-SPI-1.1** Observe and me objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using Systems International (SI) units (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius). **5-SPI-1.2** Compare and/or contrast similar and/or different characteristics (e.g., color, shape, size, texture, sound, position, change) in a given set of objects, organisms, or events.	3		

Reviewers also added explanatory notes to the alignment ratings to indicate precisely the reason for the partial or nonalignment. There were separate instruments for grades 4, 8, and 12, and within each grade level the content was divided into Earth and space science, life science, and physical science categories. Based on a combination of their scientific and grade level experience, the six reviewers worked in teams of two reviewers per grade level. When the NAEP and state grades being compared did not match (for instance, when comparing the NAEP grade 4 with Oklahoma grade 5) content statements were considered to be at the same grade for assignment of alignment ratings (1–3) and codes (such as HG, LG).

To ensure the consistent application of the crosswalk instrument by each reviewer, the alignment team attended training sessions spread over several weeks and conducted by Dr. Timms. The training comprised four sessions. Session one included a review of a previous WestEd alignment study to allow teachers to understand the scope of the project and the methodology. The team was also given an introduction to the NAEP standards and then asked to carefully read the NAEP framework

standards document before the second session. The second training session included a review and discussion of the NAEP standards and an overview of each of the REL Southwest Region's state assessment standards. Reviewers were then asked to complete an in-depth reading of one of the states' assessment standards. During the third training session, reviewers were introduced to the crosswalk instrument and asked to use it to begin performing an alignment. Reviewers then individually completed an alignment for one state on their own.

During the final training session, the teams at each grade level met to practice consensus-building and establish the criteria for assigning each rating. One criterion was to compare one NAEP standard with as many state standards as possible and to assign an overall alignment rating based upon the sum of all state standards compared with the single NAEP standard in question. Another criterion was to give a rating of 2 for alignments in which the state standard addressed only one portion (sometimes one sentence) of the NAEP statement. A third criterion was to assign ratings of 2 to alignments for which the NAEP contained more content or more detailed content than the state, or for which the state appeared to imply but not explicitly state the content found in the NAEP. If a matching standard was found at a higher state grade level than the NAEP grade level, a rating of 2 was given. If a matching state standard was found at a lower grade level but did not appear to fully address the NAEP standard, a rating of 2 was also given.

As part of the stipulated methodology, the reviewers first conducted independent reviews without consulting their partners. Each began with a review of the set of state standards to get an overall impression of their content and structure. Next, the reviewer used the crosswalk instrument to do a more detailed examination starting with an NAEP content statement and then searching the state standards for those that covered all or part the same content. The reviewer continued in this way, systematically matching the state content standards to the NAEP content statements and recording the results in the crosswalk instrument table. After all the NAEP content statements had been covered, the reviewer applied the three-point rating system to determine the level of alignment of each NAEP content statement.

When both reviewers for a grade level had completed their individual reviews, they met under the guidance of the senior reviewer to compare their ratings and reach a consensus. When they disagreed on which state standards matched a particular NAEP content statement or their ratings were not the same, they re-examined the content in question and discussed their differing viewpoints. The purpose was to reach a consensus so that there was a single alignment table for each grade that represented their combined review. The senior reviewer moderated the discussion to reinforce the established rating criteria and help reviewers achieve consensus. The alignment tables are shown in detail in appendices C—E.

When the consensus alignment tables were complete, a WestEd researcher summarized them quantitatively by calculating the average ratings organized by each of the three major NAEP content areas of physical science, life science, and Earth and space science. These average ratings are intended to be summaries of how the state's assessment content matches the NAEP content statements and to allow the reader to quickly identify possible areas for revision. In addition, the researcher wrote a report on the results, which summarized the areas of full alignment, partial alignment, and nonalignment, as well as areas where the state standards went beyond the NAEP content statements.

Test specifications review

In addition to examining content, this study compared the state assessment specifications with the NAEP 2009 test and item specifications. It was deemed important for this study to perform a review of assessment specifications because the way a test is structured and implemented often has implications for what the test is able to reveal about student understanding. The NAEP calls for a variety

of test items due to the fact that different types of items demand varying levels of cognition, knowledge, and reasoning (National Assessment Governing Board, 2006). Thus, it is important to examine the extent to which states are attempting to develop assessment items that will provide an accurate picture of what students know and can do across the range of science content and skills. In addition, it was important to examine the proportion of time that students are expected to spend on each content strand of the NAEP and the Oklahoma tests. Examining Oklahoma's and the NAEP's distribution of items in these science strands creates a snapshot of the extent to which the breadth of content in Oklahoma matches that of the NAEP.

Since the final NAEP 2009 tests have not yet been developed, it is currently possible only to compare the current Oklahoma science assessment specifications with the stipulated specifications of the future NAEP 2009 science assessment. Accordingly, the translation of standards to actual test items and the comparison of items would also be important, but these comparisons will not be possible until the public release of the NAEP 2009 assessments. Therefore, this report details analyses of the available information on state and NAEP test items, which includes item types and item distribution.

For the purpose of examining assessment specifications, WestEd researchers compared parts of the science assessment and item specifications for the 2009 NAEP document with the test blueprints for Oklahoma science assessments in the Oklahoma test specifications documents for grades 5 and 8 and end-of-instruction biology.

The NAEP science assessment and item specifications is a detailed document that covers the science content, science practices, generation and interpretation of items, types of items and administration of the assessment. For this study the review of the test specifications focused on two main things: the types of items used in the state assessment and the proportions of time that students spend on each of the main science topic areas of the NAEP. WestEd researchers used test blueprints and assessment specifications from the state and the NAEP to compare types of items and the distribution of items in each science content strand. First, differences between the NAEP and the state were examined for the types of items required on the tests (multiple-choice, constructed-response, and so on). Next, differences in the approximate amount of student time spent on each content strand (physical, life, and Earth and space science) were examined.

APPENDIX C
CONTENT ALIGNMENT FOR GRADE 4

TABLE C1
Alignment of National Assessment of Educational Progress grade 4 science and Oklahoma grade 5 standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *physical properties common to all objects and substances and physical properties common to solids, liquids and gases*			
P4.1: Objects and substances have properties. Weight (mass) and volume are properties that can be measured using appropriate tools.	**5-PS-1.1** Matter has physical properties that can be used for identification (e.g., color, texture, shape). **5-PS-1.2** Physical properties of objects can be observed, described, and measured using tools such as simple microscopes, gram spring scales, metric rulers, metric balances, and Celsius thermometers. **5-SPI-1.1** Observe and measure objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using Systems International (SI) units (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius). **5-SPI-1.2** Compare and/or contrast similar and/or different characteristics (e.g., color, shape, size, texture, sound, position, change) in a given set of objects, organisms, or events.	3		
P4.2: Objects vary in the extent to which they absorb and reflect light and conduct heat (thermal energy) and electricity.		1		
P4.3: Matter exists in several different states; the most commonly encountered are solid, liquid, and gas. Each state of matter has unique properties. For instance, gases are easily compressed while solids and liquids are not. The shape of a solid is independent of its container; liquids and gases take the shape of their containers.		1		
P4.4: Some objects are composed of a single substance; others are composed of more than one substance.		1		

(CONTINUED)

TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Oklahoma grade 5 standards

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MATTER	**P4.5:** Magnets can repel or attract other magnets. They can also attract certain nonmagnetic objects at a distance.		1		
	Changes in matter: *changes of state*				
	P4.6: One way to change matter from one state to another and back again is by heating and cooling.		1		
ENERGY	***Forms of energy:*** *examples of forms of energy*				
	P4.7: Heat (thermal energy), electricity, light, and sound are forms of energy.	**5-PS-1.3** Energy can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).	1		Does not mention forms of energy
	P4.8: Heat (thermal energy) results when substances burn, when certain kinds of materials rub against each other, and when electricity flows though wires. Metals are good conductors of heat (thermal energy) and electricity. Increasing the temperature of any substance requires the addition of energy.	**5-PS-1.3** Energy can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).	1	MD MC	OK just states "energy can be transferred in many ways"
	P4.9: Light travels in straight lines. When light strikes substances and objects through which it cannot pass, shadows result. When light travels obliquely from one substance to another (air and water), it changes direction.		1		
	P4.10: Vibrating objects produce sound. The pitch of sound can be varied by changing the rate of vibration.		1		
	Energy transfer and conservation: *electrical circuits*				
	P4.11: Electricity flowing through an electrical circuit produces magnetic effects in the wires. In an electrical circuit containing a battery, a bulb, and a bell, energy from the battery is transferred to the bulb and the bell, which in turn transfer the energy to their surroundings as light, sound, and heat (thermal energy).		1		

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MOTION	***Motion at the macroscopic level:*** *descriptions of position and motion*				
	P4.12: An object's position can be described by locating the object relative to other objects or a background. The description of an object's motion from one observer's view may be different from that reported from a different observer's view.		1		
	P4.13: An object is in motion when its position is changing. The speed of an object is defined by how far it travels divided by the amount of time it took to travel that far.		1		
	Forces affecting motion: *the association of changes in motion with forces and the association of objects falling toward Earth with gravitational force*				
	P4.14: The motion of objects can be changed by pushing or pulling. The size of the change is related to the size of the force (push or pull) and the weight (mass) of the object on which the force is exerted. When an object does not move in response to a push or a pull, it is because another push or pull (friction) is being applied by the environment.		1		
	P4.15: Earth pulls down on all objects with a force called gravity. With a few exceptions (helium filled balloons), objects fall to the ground no matter where the object is on Earth.		1		
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and development:*** *basic needs of organisms*				
	L4.1: Organisms need food, water, and air; a way to dispose of waste; and an environment in which they can live.	**5-LS-2.1** Organisms in a community, interacting populations in a common location, depend on each other for food, shelter, and reproduction.	2		"organisms depend… food, shelter & reprod" does not mention water, air, waste
	Matter and energy transformations: *the basic needs of organisms for growth*				
	L4.2: Organisms have basic needs. Animals require air, water, and a source of energy and building material for growth and repair. Plants also require light.		1		

(CONTINUED)

TABLE C1 (CONTINUED)
Alignment of National Assessment of Educational Progress grade 4 science and Oklahoma grade 5 standards

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Interdependence:*** *the interdependence of organisms*				
	L4.3: Organisms interact and are interdependent in various ways including providing food and shelter to one another. Organisms can survive only in environments in which their needs are met. Some interactions are beneficial; others are detrimental to the organism and other organisms.	**5-LS-2.1** Organisms in a community, interacting populations in a common location, depend on each other for food, shelter, and reproduction. **5-LS-2.2** Changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.	2		5-LS-2.1 is beneficial 5-LS-2.2 is detrimental Last two sentences in NAEP are not in OK
	L4.4: When the environment changes, some plants and animals survive and reproduce; others die or move to new locations.	**5-LS-2.2** Changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.	2		OK mentions "due to human interaction or natural phenomena" but is missing "move to new locations"
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *life cycles*				
	L4.5: Plants and animals have life cycles. Both plants and animals begin life and develop into adults, reproduce, and eventually die. The details of this life cycle are different for different organisms.		1		
	L4.6: Plants and animals closely resemble their parents.		1		
	Evolution and diversity: *differences and adaptations of organisms*				
	L4.7: Different kinds of organisms have characteristics that enable them to survive in different environments. Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing.		1		
Earth and space science					
EARTH IN SPACE AND TIME	***Objects in the universe:*** *patterns in the sky*				
	E4.1: Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon appears to move across the sky on a daily basis much like the sun.	**5-ESS-3.3** Earth is the third planet from the Sun in a system that includes the moon, the Sun, and eight other planets.	1		Only identifies earth, moon, sun & 8 planets but doesn't relate to movement

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH IN SPACE AND TIME	**E4.2:** The observable shape of the moon changes from day to day in a cycle that lasts about a month.		1		
	History of Earth: *evidence of change*				
	E4.3: The surface of Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.	**5-ESS-3.1** Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers.	1		All that relates is "soil, weathered rock"
EARTH STRUCTURES	***Properties of Earth materials:*** *natural and human-made materials*				
	E4.4: Earth materials that occur in nature include rocks, minerals, soils, water, and the gases of the atmosphere.	**5-ESS-3.1** Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers.	2	IC	OK just deals with defining soil
	E4.5: Natural materials have different properties, which sustain plant and animal life.		1		
	E4.6: Some Earth materials have properties that make them useful either in their present form or designed and modified to solve human problems and enhance the quality of life, as in the case of materials used for building or fuels used for heating and transportation.		1		
EARTH SYSTEMS	***Energy in Earth systems:*** *role of the sun*				
	E4.7: The sun warms the land, air, and water and helps plants grow.		1		
	Climate and weather: *local weather*				
	E4.8: Weather changes from day to day and over the seasons.	**5-ESS-3.2** Weather exhibits daily and seasonal patterns (i.e., air temperature, cloud type, wind direction, wind speed, and precipitation).	3		
	E4.9: Scientists use tools for observing, recording, and predicting weather changes from day to day and over the seasons.	**5-SPI-1.1** Observe and measure objects, organisms, and/or events (e.g., mass, length, time, volume, temperature) using Systems International (SI) units (i.e., grams, milligrams, meters, millimeters, centimeters, kilometers, liters, milliliters, and degrees Celsius).	1		References liters and degrees Celcius

(CONTINUED)

TABLE C1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 4 science and Oklahoma grade 5 standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
	Biogeochemical cycles: *uses of Earth resources*			
	E4.10: The supply of many Earth resources such as fuels, metals, fresh water, and farmland is limited. Humans have devised methods for extending the use of Earth resources through recycling, reuse, and renewal.	1		
	E4.11: Humans depend on their natural and constructed environment. Humans change environments in ways that can either be beneficial or detrimental for themselves and other organisms.	1		

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE C2

Oklahoma grade 5 standards not covered by National Assessment of Educational Progress grade 4 content

Content area	Oklahoma grade 5 standards
Science processes and inquiry	Classify 5-SPI-2.1, 2.2 Experiment 5-SPI-3.1*, 3.2, 3.3*, 3.4, Interpret 5-SPI-4.1*, 4.2, 4.3, 4.4 Inquiry 5-SPI-5.1, 5.2, 5.3, 5.4 (all opt *)
Physical science	All used
Life science	All used
Earth and space science	All used

APPENDIX D
CONTENT ALIGNMENT FOR GRADE 8

TABLE D1

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *chemical properties, particulate nature of matter, and the Periodic Table of Elements*			
	P8.1: Properties of solids, liquids, and gases are explained by a model of matter that is composed of tiny particles in motion.	1		
	P8.2: Chemical properties of substances are explained by the arrangement of atoms and molecules.	1		
	P8.3: All substances are composed of one or more of approximately one hundred elements. The Periodic Table organizes the elements into families of elements with similar properties.	1		
	P8.4: Elements are a class of substances composed of a single kind of atom. Compounds are composed of two or more different elements. Each element and compound has physical and chemical properties, such as boiling point, density, color, and conductivity, which are independent of the amount of the sample.	**8-PS-1.2** Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, density, and hardness). In chemical reactions and physical changes, matter is conserved (e.g., compare and contrast physical and chemical changes).	2	MD MC	*only this sentence is covered
	P8.5: Substances are classified according to their physical and chemical properties. Metals and acids are examples of such classes. Metals are a class of elements that exhibit common physical properties such as conductivity and common chemical properties such as reacting with nonmetals to produce salts. Acids are a class of compounds that exhibit common chemical properties including a sour taste, characteristic color changes with litmus and other acid/base indicators, and the tendency to react with bases to produce a salt and water.	**5-PS-1.1 Matter** has physical properties that can be used for identification (e.g., color, texture, shape).	2	MD MC	State standard only supports 1st sentence of NAEP

TABLE D1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MATTER	***Changes in matter:*** *physical and chemical changes and conservation of mass*				
	P8.6: Changes of state are explained by a model of matter composed of tiny particles that are in motion. When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure. Mass is conserved when substances undergo changes of state.	**8-PS-1.2 Matter** has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, density, and hardness). In chemical reactions and physical changes, matter is conserved (e.g., compare and contrast physical and chemical changes).	2	MC MD	** only this part is addressed
	P8.7: Chemical changes can occur when two substances, elements, or compounds react and produce one or more different substances, whose physical and chemical properties are different from the reacting substances. When substances undergo chemical change, the number and kinds of atoms in the reactants are the same as the number and kinds of atoms in the products. Mass is conserved when substances undergo chemical change. The mass of the reactants is the same as the mass of the products.	**8-PS-1.1** Substances react chemically with other substances to form new substances with different characteristics (e.g., rusting, burning, reaction between baking soda and vinegar). **8-PS-1.2** Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, density, and hardness). In chemical reactions and physical changes, matter is conserved (e.g., compare and contrast physical and chemical changes). **Bio-CS-5.2*** As matter and energy flow through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures. Matter and energy are conserved in each change (i.e., water cycle, carbon cycle, nitrogen cycle, food webs, and energy pyramids).	2	IC MD	*refers to living systems
ENERGY	***Forms of energy*:** *kinetic energy, potential energy, and light energy from the sun*				
	P8.8: Objects and substances in motion have kinetic energy. For example, a moving baseball can break a window; water flowing down a stream moves pebbles and floating objects along with it.	**5-PS-1.3** Energy can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).	2	LG MC MD	

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
ENERGY	**P8.9:** Three forms of potential energy are gravitational, elastic, and chemical. Gravitational potential energy changes in a system as the relative positions of objects are changed. Objects can have elastic potential energy due to their compression, or chemical potential energy due to the nature and arrangement of the atoms.		1		
	P8.10: Energy is transferred from place to place. Light energy from the sun travels through space to Earth (radiation). Thermal energy travels from a flame through the metal of a cooking pan to the water in the pan (conduction). Air warmed by a fireplace moves around a room (convection). Waves—including sound and seismic waves, waves on water, and light waves—have energy and transfer energy when they interact with matter.	**5-PS-1.3 Energy** can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).	2	LG MC MD	
	P8.11: A tiny fraction of the light energy from the sun reaches Earth. Light energy from the sun is Earth's primary source of energy, heating Earth surfaces and providing the energy that results in wind, ocean currents, and storms.	**5-PS-1.3** Energy can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).	2	LG MC MD	
	Energy transfer and conservation: *energy transfer and conservation of energy*				
	P8.12: When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. For example, as an object falls, its potential energy decreases as its speed, and consequently, its kinetic energy increases. While an object is falling, some of the object's kinetic energy is transferred to the medium through which it falls, setting the medium into motion and heating it.		1		
	P8.13: Nuclear reactions take place in the sun. In plants, light from the sun is transferre3d to oxygen and carbon compounds, which, in combination, have chemical potential energy (photosynthesis).		1		

(CONTINUED)

TABLE D1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MOTION	***Motion at the macroscopic level:*** *speed as a quantitative description of motion and graphical representations of speed*				
	P8.14: An object's motion can be described by its speed and the direction in which it is moving. An object's position can be measured and graphed as a function of time. An object's speed can be measured and graphed as a function of time.	**8-PS-2.1** The motion of an object can be measured. The position of an object, its speed and direction can be represented on a graph.	3		
	Forces affecting motion: *qualitative descriptions of magnitude and direction as characteristics of forces, addition of forces, contact forces, forces that act at a distance, and net force on an object and its relationship to the object's motion*				
	P8.15: Some forces between objects act when the objects are in direct contact or when they are not touching. Magnetic, electrical, and gravitational forces can act at a distance.		1		
	P8.16: Forces have magnitude and direction. Forces can be added. The net force on an object is the sum of all the forces acting on the object. A nonzero net force on an object changes the object's motion; that is, the object's speed and/or direction of motion changes. A net force of zero on an object does not change the object's motion; that is, the object remains at rest or continues to move at a constant speed in a straight line.	**8-PS-2.2** An object that is not being subjected to a net force will continue to move at a constant velocity (in a straight line and at a constant speed).	2	MC MD	* and ** parts not addressed
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and development: basic needs of organisms:*** *the levels of organization of living systems*				
	L8.1: All organisms are composed of cells, from just one cell to many cells. About two-thirds of the weight of cells is accounted for by water, which gives cells many of their properties. In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms.	**BIO-CS-1.2 Cells** can differentiate and may develop into complex multicellular organisms (i.e., cells, tissues, organs, organ systems, organisms).	1	HG	
	L8.2: Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues of an embryo.		1		

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Matter and energy transformations:*** *the role of carbon compounds in growth and metabolism*			
L8.3: Cells carry out the many functions needed to sustain life. They grow and divide, thereby producing more cells. Food is used to provide energy for the work that cells do and is a source of the molecular building blocks from which needed materials are assembled.		1		
L8.4: Plants are producers—they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars along with minerals from the soil to form fats, proteins, and carbohydrates. These products can be used immediately, incorporated into the plant's cells as the plant grows, or stored for later use.		1		
L8.5: All animals, including humans, are consumers that meet their energy needs by eating other organisms or their products. Consumers break down the structures of the organisms they eat to make the materials they need to grow and function. Decomposers, including bacteria and fungi, use dead organisms or their products to meet their energy needs.	**5-LS-2.1 Organisms** in a community, interacting populations in a common location, depend on each other for food, shelter, and reproduction.	1	LG IC	
	Interdependence: *specific types of interdependence*			
L8.6: Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or, one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.	**5-LS-2.1** Organisms in a community, interacting populations in a common location, depend on each other for food, shelter, and reproduction. **Bio-CS-4.2 Organisms** both cooperate and compete in ecosystems (i.e., parasitism and symbiosis).	2	MD MC HG	Doesn't address specific relationships or interactions
L8.7: The number of organisms and populations an ecosystem can support depends on the biotic resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition.	**Bio-CS-4.3** Living organisms have the capacity to produce populations of infinite size, but environments and resources limit population size (i.e., carrying capacity and limiting factors).	2	MD	Doesn't mention biotic factors

(CONTINUED)

TABLE D1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

	NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	**L8.8:** All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organisms or other organisms, whereas others are beneficial.	**5-LS-2.2 Changes** in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.	2	LG	Covered in 5th grade
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *reproduction and the influence of heredity and the environment on an offspring's characteristics*				
	L8.9: Reproduction is a characteristic of all living systems**;** because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.		1		
	L8.10: The characteristics of organisms are influenced by heredity and environment. For some characteristics, inheritance is more important; for other characteristics, interactions with the environment are more important.		1		

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science				
CHANGES IN LIVING SYSTEMS	***Evolution and diversity:*** *preferential survival and relatedness of organisms*			
L8.11: Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring. When an environment changes, the advantage or disadvantage of characteristics can change. Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the Earth no longer exist.	***8-LS-3.2** Organisms have a great variety of internal and external structures that enable them to survive in a specific habitat such as echolocation of bats and seed dispersal methods. **Bio-CS-3.2** Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology, which may enhance or limit the survival and reproductive success in a particular environment.	2	MC HG	Doesn't mention extinction or fossils
L8.12: Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.	**8-SPI-2.1** Using observable properties, place an object, organism, and/or event into a classification system (e.g., dichotomous keys). **8-LS-3.1** By classifying organisms, biologists consider details of internal and external structure. **Bio-PI-2.2** Identify the properties by which a biological classification system is based.	3		
Earth and space science				
EARTH IN SPACE AND TIME	***Objects in the universe:*** *a model of the solar system*			
E8.1: In contrast to an earlier theory that Earth is the center of the universe, it is now known that the sun, an average star, is the central and largest body in the solar system. Earth is the third planet from the sun in a system that includes eight other planets and their moons, as well as smaller objects, such as asteroids and comets.	**5-ESS-3.3** Earth is the third planet from the Sun in a system that includes the moon, the Sun, and eight other planets.	2	LG MC	Only second sentence is addressed
E8.2: Gravity is the force that keeps most objects in the solar system in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.	**8-ESS-4.3** Gravity is the force that governs the motion of the solar system and holds us to the earth's surface.	2	MD MC	Only 1st sentence is addressed

(CONTINUED)

TABLE D1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science				
EARTH STRUCTURES	***History of Earth:*** *estimating the timing and sequence of geologic events*			
	E8.3: Fossils provide important evidence of how life and environmental conditions have changed in a given location.	**8-ESS-5.2** Fossils provide important evidence of how life and environmental conditions have changed.	3	(IC)	
	E8.4: Earth processes seen today, such as erosion and mountain building, made possible the measurement of geologic time through methods such as observing rock sequences and using fossils to correlate the sequences at various locations.		1		
	Properties of Earth materials: *soil analysis and layers of the atmosphere*				
	E8.5: Rocks and rock formations bear evidence of the minerals, materials, temperature/pressure conditions, and forces that created them. Some formations show evidence that they were deposited by volcanic eruptions. Others are composed of sand and smaller particles buried and cemented by dissolved minerals to form solid rock again. Still others show evidence that they were once earlier rock types that were exposed to heat and pressure until they changed shape and in some cases melted and recrystallized.	**8-ESS-4.2** The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its form changes.	2	MC MD	State does not mention minerals, temperature, crystallization, etc
	E8.6: Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers with each having a different chemical composition and texture.	**5-ESS-3.1** Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers.	2	LG MC	( ) = not addressed
	E8.7: The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has a different physical and chemical composition at different elevations.		1		
	Tectonics: *the basics of tectonic theory and Earth magnetism*				
	E8.8: The Earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.		1		ESS 8.6.1—Oklahoma only says identify and diagram (too general)

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH STRUCTURES	**E8.9:** Lithospheric plates on the scale of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.		1		NAEP more specific
	E8.10: Earth as a whole has a magnetic field that is detectable at the surface with a compass. Earth's magnetic field is similar to the field of a natural or human-made magnet with north and south poles and lines of force. For thousands of years, people have used compasses to aid in navigation on land and sea.		1		
EARTH SYSTEMS	***Energy in Earth systems:*** *the sun's observable effects*				
	E8.11: The sun is the major source of energy for phenomena on Earth's surface. The sun provides energy for plants to *grow and **drives convection within the atmosphere and oceans, producing winds, ocean currents, and the water cycle.		1		
	E8.12: Seasons result from annual variations in the intensity of sunlight and length of day, due to the tilt of Earth's rotation axis relative to the plane of its yearly orbit around the sun.		1		
	Climate and Weather: *global weather patterns*				
	E8.13: Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate because water in the oceans holds a large amount of heat.		1		
	Biogeochemical cycles: *natural and human-induced changes in Earth materials and systems*				
	E8.14: Water, which covers the majority of Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from Earth's surface, rises and cools as it moves to higher elevations, condenses as clouds, falls as rain or snow, and collects in lakes, oceans, soil, and underground.		1		

(CONTINUED)

TABLE D1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 8 science and Oklahoma grade 7 standards

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH SYSTEMS	**E8.15:** Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed Earth's land, oceans, and atmosphere. Studies of plant and animal populations have shown that such activities can reduce the number and variety of wild plants and animals and sometimes result in the extinction of species.	**5-LS-2.2** Changes in environmental conditions due to human interactions or natural phenomena can affect the survival of individual organisms and/or entire species.	2	MC	Significant portions not addressed

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE D2

Oklahoma grade 8 standards not covered by National Assessment of Educational Progress grade 8 content

Content area	Oklahoma grade 8 standards
Science processes and inquiry	8-SPI-1.1, 8-SPI-1.2, 8-SPI-1.3 8-SPI-2.2 8-SPI-3.1, .2, .3, .4, .5, .6 8-SPI-4.1, .2, .3, .4, .5 8-SPI-5.1, .2, .3, .4
Physical science	—
Life science	—
Earth and space science	8-ESS-4.1 8-ESS-5.1

APPENDIX E
CONTENT ALIGNMENT FOR GRADE 12

TABLE E1

Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science				
MATTER	***Properties of matter:*** *characteristics of subatomic particles and atomic structure*			
	P12.1: Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged and the strength of the forces of attraction between the atoms, ions, or molecules.	1		
	P12.2: Electrons, protons, and neutrons are parts of the atom and have measurable properties including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.	1		
	P12.3: In the Periodic Table, elements are arranged according to the number of protons (called the atomic number). This organization illustrates commonality and patterns of physical and chemical properties among the elements.	1		
	P12.4: In a neutral atom, the positively charged nucleus is surrounded by the same number of negatively charged electrons. Atoms of an element whose nuclei have different numbers of neutrons are called isotopes.	1		
	Changes in matter: *particulate nature of matter, unique physical characteristics of water, and changes at the atomic and molecular level during chemical changes*			
	P12.5: Changes of state require a transfer of energy. Water has a very high specific heat, meaning it can absorb a large amount of energy while producing only small changes in temperature.	1		

TABLE E1 (CONTINUED)
Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MATTER	**P12.6:** An atom's electron configuration, particularly of the outermost electrons, determines how the atom can interact with other atoms. The interactions between atoms that hold them together in molecules or between oppositely charged ions are called chemical bonds.		1		
	P12.7: A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond. An important example is carbon atoms, which can bond to one another in chains, rings, and branching networks to form, along with other kinds of atoms—hydrogen, oxygen, nitrogen, and sulfur—a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.		1		
ENERGY	***Forms of energy*:** *nuclear energy and waves*				
	P12.8: Atoms and molecules that compose matter are in constant motion (translational, rotational, or vibrational).		1		
	P12.9: Energy may be transferred from one object to another during collisions.		1		
	P12.10: Electromagnetic waves are produced by changing the motion of charges or by changing magnetic fields. The energy of electromagnetic waves is transferred to matter in packets. The energy content of the packets is directly proportional to the frequency of the electromagnetic waves.		1		

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
ENERGY	**P12.11:** Fission and fusion are reactions involving changes in the nuclei of atoms. Fission is the splitting of a large nucleus into smaller nuclei and particles. Fusion involves joining of two relatively light nuclei at extremely high temperature and pressure. Fusion is the process responsible for the energy of the sun and other stars.		1		
	Energy transfer and conservation: *translational, rotational, and vibrational energy of atoms and molecules, and chemical and nuclear reactions*				
	P12.12: Heating increases the translational, rotational, and vibrational energy of the atoms composing elements and the molecules or ions composing compounds. As the translational energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a sample of a crystalline solid increases the vibrational energy of the atoms, molecules, or ions. When the vibrational energy becomes great enough, the crystalline structure breaks down and the solid melts.		1		
	P12.13: The potential energy of an object on Earth's surface is increased when the object's position is changed from one closer to Earth's surface to one farther from Earth's surface.		1		
	P12.14: Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).		1		
	P12.15: Nuclear reactions—fission and fusion—convert very small amounts of matter into appreciable amounts of energy.		1		
	P12.16: Total energy is conserved in a closed system.		1		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MOTION	***Motion at the macroscopic level:*** *velocity and acceleration as quantitative descriptions of motion and the representation of linear velocity and acceleration in tables and graphs*				
	P12.17: The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time.		1		
	P12.18: Objects undergo different kinds of motion—translational, rotational, and vibrational.		1		
	Forces affecting motion: *quantitative descriptions of universal gravitational and electric forces, and relationships among force, mass, and acceleration*				
	P12.19: The motion of an object changes only when a net force is applied.		1		
	P12.20: The magnitude of acceleration of an object depends directly on the strength of the net force and inversely on the mass of the object. This relationship ($a=F_{net}/m$) is independent of the nature of the force.		1		
	P12.21: Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first object. In closed systems, momentum is the quantity of motion that is conserved. Conservation of momentum can be used to help validate the relationship $a=F_{net}/m$.		1		
	P12.22: Gravitation is a universal attractive force that each mass exerts on any other mass. The strength of the gravitational force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.		1		

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Physical science					
MOTION	**P12.23:** Electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the electric force is proportional to the magnitudes of the charges and inversely proportional to the square of the distance between them. Between any two charged particles, the electric force is vastly greater than the gravitational force.		1		
Life science					
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Organization and Development:*** *basic needs of organisms: the chemical basis of living systems*				
	L12.1: Living systems are made of complex molecules (including carbohydrates, fats, proteins, and nucleic acids) that consist mostly of a few elements, especially carbon, hydrogen, oxygen, nitrogen, and phosphorous.		1		
	L12.2: Cellular processes are carried out by many different types of molecules, mostly proteins. Protein molecules are long, usually folded chains made from combinations of amino-acid molecules. Protein molecules assemble fats and carbohydrates and carry out other cellular functions. The function of each protein molecule depends on its specific sequence of amino acids and the shape of the molecule.		1		
	L12.3: Cellular processes are regulated both internally and externally by environments in which cells exist, including local environments that lead to cell differentiation during the development of multicellular organisms. During the development of complex multicellular organisms, cell differentiation is regulated through the expression of different genes.	**Bio-CS-1.2** Cells can differentiate and may develop into complex multicellular organisms (i.e., cells, tissues, organs, organ systems, organisms).	2	MC	NAEP goes into more depth about cellular process and regulation by internal and external environments.

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Matter and energy transformations:*** *the chemical basis of matter and energy transformation in living systems*			
L12.4: Plants have the capability (through photosynthesis) to take energy from light to form higher energy sugar molecules containing carbon, hydrogen, and oxygen from lower energy molecules. These sugar molecules can be used to make amino acids and other carbon-containing (organic) molecules and assembled into larger molecules with biological activity (including proteins, DNA, carbohydrates, and fats).	**Bio-CS-5.1** The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism (i.e., photosynthesis and cellular respiration).	2	IC	OK sort of covers the NAEP standards, but doesn't state it in the same way. NAEP goes into a lot more detail. OK does not mention amino acids, but refers to photosynthesis and cellular respiration
L12.5: The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in an ecosystem, some energy is stored in newly made structures, but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.	**Bio-CS-5.2** As matter and energy flow through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures. Matter and energy are conserved in each change (i.e., water cycle, carbon cycle, nitrogen cycle, food webs, and energy pyramids).	3		OK states matter and energy are conserved in each change…
L12.6: As matter cycles and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.	**Bio-CS-4.1** Matter on the earth cycles among the living and nonliving components of the biosphere.	2	MD	NAEP is more detailed.

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science				
STRUCTURES AND FUNCTIONS OF LIVING SYSTEMS	***Interdependence:*** *consequences of interdependence*			
L12.7: Although the interrelationships and interdependence of organisms may generate biological communities in ecosystems that are stable for hundreds or thousands of years, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. The impact of the human species has major consequences for other species.	**Bio-CS-4.3** Living organisms have the capacity to produce populations of infinite size, but environments and resources limit population size (i.e., carrying capacity and limiting factors). **Bio-CS-4.2** Organisms both cooperate and compete in ecosystems (i.e., parasitism and symbiosis).	2	IC	Carrying capacity and limiting factors affect how relationships occur in the ecosystems, but this doesn't explain climate changes or migration or human impact. OK only mentions organisms cooperate and compete in ecosystems
CHANGES IN LIVING SYSTEMS	***Heredity and reproduction:*** *the molecular basis of heredity*			
L12.8: Hereditary information is contained in genes, located in the chromosomes of each cell. A human cell contains many thousands of different genes. One or many genes can determine an inherited trait of an individual, and a single gene can influence more than one trait.	**Bio-CS-2.1** Cells function according to the information contained in the master code of DNA (i.e., cell cycle, DNA to DNA, and DNA to RNA). Transfer RNA and protein synthesis will be taught in life science courses with rigor greater than Biology I.	2	MC	OK covers the first sentence of NAEP standard.
L12.9: The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.	**Bio-CS-2.1** Cells function according to the information contained in the master code of DNA (i.e., cell cycle, DNA to DNA, and DNA to RNA). Transfer RNA and protein synthesis will be taught in life science courses with rigor greater than Biology I.	2	MC	OK doesn't cover protein synthesis in these standards.
L12.10: Sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.	**Bio-CS-2.2** A sorting and recombination of genes in reproduction results in a great variety of possible gene combinations from the offspring of any two parents (i.e., Punnett squares and pedigrees). Students will understand the following concepts in a single trait cross: alleles, dominant trait, recessive trait, phenotype, genotype, homozygous, and heterozygous.	3		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Life science				
CHANGES IN LIVING SYSTEMS	***Evolution and Diversity:*** *the mechanisms of evolutionary change and the history of life on Earth*			
L12.11: Modern ideas about evolution (including natural selection and common descent) provide a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.		1		
L12.12: Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.	**Bio-CS-3.1** Different species might look dissimilar, but the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry (i.e., homologous and analogous structures).	2	IC	OK doesn't state molecular evidence directly, but it can be assumed.
L12.13: Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection from environmental pressure of those organisms better able to survive and leave offspring.	**Bio-CS-3.2** Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology, which may enhance or limit the survival and reproductive success in a particular environment. **Bio-CS-6.2** Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. Broad patterns of behavior exhibited by animals have changed over time to ensure reproductive success.	2	MC	Bio-CS-6.2 covers the response to stimuli and interactions with species Bio-CS-3.2 is implied. OK mentions adaptation, variation and changes in structures, behaviors or physiology OK mentions adaptation, variation and changes in structures, behaviors or physiology
Earth and space science				
EARTH IN SPACE AND TIME	***Objects in the Universe:*** *a vision of the universe*			
E12.1: The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin approximately 13.7 billion years ago when the universe began in a hot, dense state. According to this theory, the universe has been expanding ever since.		1		

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH IN SPACE AND TIME	**E12.2:** Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars and billions of galaxies.		1		
	E12.3: Stars, like the sun, transform matter into energy in nuclear reactions. When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy. These and other processes in stars have led to the formation of all the other elements.		1		
	History of Earth: *theories about Earth's history*				
	E12.4: Early methods of determining geologic time, such as the use of index fossils and stratigraphic sequences, allowed for the relative dating of geological events. However, absolute dating was impossible until the discovery that certain radioactive isotopes in rocks have known decay rates, making it possible to determine how many years ago a given rock sample formed.		1		
	E12.5: Theories of planet formation and radioactive dating of meteorites and lunar samples have led to the conclusion that the sun, Earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.		1		
	E12.6: Early Earth was very different from today's planet. Evidence for one-celled forms of life—the bacteria—extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of Earth's atmosphere, which did not originally contain molecular oxygen.		1		
	E12.7: Earth's current structure has been influenced by both sporadic and gradual events. Changes caused by violent earthquakes and volcanic eruptions can be observed on a human time scale, but many geological processes, such as the building of mountain chains and shifting of entire continents, take place over hundreds of millions of years.		1		

(CONTINUED)

TABLE E1 (CONTINUED)

Alignment of National Assessment of Educational Progress grade 12 science and Oklahoma end-of-instruction biology standards

NAEP science standards	Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science				
EARTH STRUCTURES	***Tectonics:*** *the basics of tectonic theory and Earth magnetism*			
	E12.8: Mapping of the Mid-Atlantic Ridge, evidence of sea floor spreading, and subduction provided crucial evidence in support of the theory of plate tectonics. The theory currently explains plate motion as follows: the outward transfer of Earth's internal heat propels the plates comprising Earth's surface across the face of the globe. Plates are pushed apart where magma rises to form mid-ocean ridges, and the edges of plates are pulled back down where Earth materials sink into the crust at deep trenches.	1		
EARTH SYSTEMS	***Energy in earth systems:*** *internal and external sources of energy in Earth systems*			
	E12.9: Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from Earth's original formation.	1		
	Climate and Weather: *systems that influence climate*			
	E12.10: Climate is determined by energy transfer from the sun at and near Earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover, atmospheric gases, and Earth's rotation, as well as static conditions such as the positions of mountain ranges and of oceans, seas, and lakes.	1		
	Biogeochemical cycles: *biogeochemical cycles in Earth systems*			
	E12.11: Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Most elements can exist in several different chemical forms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of biogeochemical cycles.	1		

NAEP science standards		Oklahoma content	Overall rating[a]	Code[b]	Notes
Earth and space science					
EARTH SYSTEMS	**E12.12:** Movement of matter through Earth's systems is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in coal and other fossil fuels, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life.		1		
	E12.13: Natural ecosystems provide an array of basic processes that affect humans. These processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients.		1		

a. Rating is based on a scale of 1 to 3, where 1 indicates that state standards do not address NAEP content statement, 2 that state standards partially address NAEP content statement, and 3 that state standards fully address or exceed NAEP content statement by targeted grade level.

b. Codes are IC (implied content), LG (content covered at a lower grade level), HG (content covered at a higher grade level), MC (more content), and MD (more detailed content). See appendix C for further information.

TABLE E2

Oklahoma biology standards not covered by National Assessment of Educational Progress grade 12 content

Content area	Oklahoma biology standards
Process and inquiry standards and objectives	bio-PI-1.1, Bio-PI-1.2, Bio-PI-1.3 Bio-PI-2.1, Bio-PI-2.2 Bio-PI-3.1, Bio-PI-3.2, Bio-PI-3.3, Bio-PI-3.4, Bio-PI-3.5 Bio-PI-4.1, Bio-PI-4.2, Bio-PI-4.3, Bio-PI-4.4, Bio-PI-4.5, Bio-PI-4.6, Bio-PI-4.7, Bio-PI-4.8 Bio-PI-5.1, Bio-PI-5.2, Bio-PI-5.3 Bio-PI-6.1, Bio-PI-6.2, Bio-PI-6.3, Bio-PI-6.4
Content standards and objectives—biology I	Bio-CS-1.1 Bio-CS-6.1

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