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Comparative Analysis of the NAEP Science Framework and State Science Standards

Technical Report

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Authors:	Emily R. Dickinson Monica Gribben Sheila R. Schultz Elisabeth Spratto Anne Woods	**Date:**	February 2, 2021

Headquarters: 66 Canal Center Plaza, Suite 700, Alexandria, VA 22314 | Phone: 703.549.3611 | humrro.org

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Executive Summary

Introduction

The National Assessment of Educational Progress (NAEP) Science Framework was last updated in 2005, and it was first implemented for the 2009 NAEP Science Assessment (National Assessment Governing Board, 2019). The National Research Council's Framework for K–12 Science Education (NRC, 2012) and the Next Generation Science Standards (NGSS) were released in 2013, and in 2014, NAEP released an analysis of how NGSS compared with the NAEP Science Framework. To inform a comprehensive picture of state science standards, the National Assessment Governing Board (Governing Board) requested that the Human Resources Research Organization (HumRRO) conduct a comparative analysis of the NAEP Science Framework and other state science standards. This analysis in conjunction with the previous NGSS-NAEP comparison will inform the Governing Board's future decision about whether and how to update the NAEP Science Framework.

Methods

The method used to conduct this comparative study relied heavily on obtaining experts' judgments regarding the overlap of subject matter between the NAEP Science Framework and states' science standards. Thus, the focus was on a comparison of the content topics addressed by the standards. When students do science, they explore content topics through a variety of science practices. To determine the extent to which NAEP and states expect student engagement with a similar range of science practices, HumRRO collected judgments about the NAEP science practices reflected in the state content standards as a secondary focus.

The comparative analysis included only the standards from states that did not fully adopt the NGSS (i.e., six states) and those that partially adopted the NGSS (i.e., 24 states, including the Department of Defense schools). The science standards from the partial NGSS adopting states, which are based on the NRC Framework, were included in the study. However, NGSS performance expectations were excluded from the analysis, given the previous study comparing NAEP and NGSS.

A computer algorithm was used to identify state content statements that matched verbatim any NGSS performance expectations. A similar computer algorithm was then used to identify content statements from different states that were nearly verbatim. Finally, HumRRO science content experts reviewed the state content statements identified by the algorithm that were not NGSS performance expectations. This removed obvious content redundancy relative to NGSS or content that clearly did not overlap with NAEP while confirming the statements on which the experts (external to HumRRO; hereafter referred to as, "the experts") would provide judgments focused on content. Table ES1 summarizes the number of content statements per grade that were reviewed by HumRRO and on which the experts provided judgments.

The experts who provided the comparative judgments were familiar with the NGSS as well as multiple states' science standards, had experience with standards design and implementation, had experience teaching science content, and previously or currently participated in national or multi-state science committees.

Table ES1. Number of State Science Content Statements Per Domain and Grade Level

Grade Level	Number of State Content Statements Reviewed by HumRRO	Number of State Content Statements Presented to Experts	Percentage of State Content Statements Presented to Experts per Domain
4	821	627	*76.4%*
8	2,034	1,515	*74.4%*
12	2,495	1,379	*55.2%*

The experts participated in a virtual training and calibration session prior to providing their overlap judgments, where they (a) rated the level of overlap between several paired NAEP and state content statements and (b) identified the NAEP science practice that was reflected in the state content statements. HumRRO instructed the experts to treat the NAEP content statement as the "base" statement and to compare each paired state content statement to the NAEP statement to determine any content overlap. After the training and calibration session, the experts carefully and independently reviewed the paired NAEP and state content statements, determined the essential content covered in each, and rated the level of overlap in science content between the two. Essential content was defined as the most important concepts presented in the statement that fully capture what the statement intends to measure.

Based on their independent comparisons of essential content in the paired NAEP and state content statements, the experts determined if the content covered in the NAEP statement was fully covered by the state statement (full overlap), partially covered by the state statement (partial overlap), or not covered at all by the state statement (no overlap). Table ES2 presents the definitions of each of the overlap rating categories.

Table ES2. Summary of Content Overlap Rating Categories

Rating	Summary
Full overlap	All essential content in the NAEP content statement is contained in the state content statement.
Partial overlap	Some essential content in the state content statement is not in the NAEP content statement.
No overlap	The key content measured by the two content statements is different.

In addition to the content overlap ratings, the experts identified the NAEP science practice they believed was reflected in each state content statement. The experts first identified what practices students were expected to engage in based on the language of the state content statement. Then, based on the definitions of the NAEP science practices and example NAEP performance expectations, the experts determined which NAEP science practice was reflected in that state content statement.

HumRRO analyzed the experts' independent ratings to determine when they disagreed and to identify the paired NAEP and state content statements that required adjudication. Adjudication of content ratings was prioritized over adjudication of science practices. Rating discrepancies on science practices were adjudicated after all content discrepancies were resolved.

The experts participated in separate grade-level virtual adjudication meetings to determine the final content overlap rating for each paired NAEP and state content statement. The rating was considered final when two of the three experts independently provided the same content overlap rating.

Experts also contributed to developing a consensus statement for each grade. In addition to providing context for the content overlap ratings, the consensus statements provide a brief general description of the overall science content covered at each grade as well as content covered by specific science domains, with a focus on content states covered but the NAEP did not.

Results

In grades 4 and 8, the largest percentages of state content statements were rated by the experts as fully overlapping. This indicates that for most of the state content statements, all the essential content of the state statement was also contained in the paired NAEP content statement. Also, in grades 4 and 8, relatively large percentages of state content statements were rated by the experts as partially overlapping. This indicates that for many state content statements, some of the essential content was contained in the paired NAEP content statement, but the state content statement contained additional content that was not in the paired NAEP content statement.

In grade 12, the largest percentage of state content statements was rated by the experts as partially overlapping, indicating that for most state content statements, some of the essential content was contained in the paired NAEP content statement, but the state content statement contained additional content that was not in the paired NAEP content statement. The smallest percentage of state content statements were rated by the experts as fully overlapping, indicating that for a relatively small number of state content statements, all the essential content was also contained in the paired NAEP content statement.

Table ES3 presents a summary by grade and domain of the experts' content overlap ratings. Included in the table are the percentages of overlap ratings based on all content statements reviewed (the *All* columns). These percentages include the state content statements that were determined by HumRRO experts to not overlap with any NAEP content statement. These columns indicate higher percentages of no overlap ratings, because by design expert panelists did not review content statements that were determined by HumRRO to be not overlapping with a NAEP content statement.

Across the three grades experts, found that state content statements reflected the range of NAEP science practices to some extent. In grades 4 and 8, experts rated the largest percentage of state content statements as Identifying Science Principles, whereas experts rated the largest percentage in grade 12 state content statements as Using Science Principles. This pattern of ratings makes sense considering that students at higher grade levels may be expected to engage in more application of science principles and practices. Table ES4 presents experts' consensus ratings about the NAEP science practices reflected in the state content statements they reviewed.

Table ES3. NAEP-State Science Content Overlap Ratings by Grade and Domain: All Statements and Statements Reviewed by Experts

Grade	Domain	No Overlap % (N)		Partial Overlap % (N)		Full Overlap % (N)	
		All	Experts	All	Experts	All	Experts
4	ESS	37.0% (112)	8.6% (18)	39.7% (83)	27.4% (83)	35.6% (108)	51.7% (108)
4	LS	22.6% (54)	9.3% (19)	40.7% (83)	34.7% (83)	42.7% (102)	50% (102)
4	PS	31.9% (89)	11.2% (24)	36.4% (78)	28.0% (78)	40.1% (112)	52.3% (112)
Total Grade 4		31.1% (255)	9.7% (61)	38.9% (244)	29.7% (244)	39.2% (322)	51.4% (322)
8	ESS	25.4% (144)	8.2% (38)	42.2% (195)	34.3% (195)	40.3% (229)	49.6% (229)
8	LS	29.5% (205)	7.9% (42)	52% (277)	39.8% (277)	30.7% (214)	40.2% (214)
8	PS	38.6% (297)	9% (47)	33.7% (175)	22.7% (175)	38.7% (298)	57.3% (298)
Total Grade 8		31.8% (646)	8.4% (127)	42.7% (647)	31.8% (647)	36.4% (741)	48.9% (741)
12	ESS	58.6% (365)	12.5% (37)	75.9% (224)	36.0% (224)	5.5% (34)	11.5% (34)
12	LS	51.4% (408)	15.5% (71)	78.8% (360)	45.3% (360)	3.3% (26)	5.7% (26)
12	PS	56.5% (609)	25.2% (158)	66% (414)	38.4% (414)	5.1% (55)	8.8% (55)
Total Grade 12		55.4% (1,382)	19.3% (266)	72.4% (998)	40.0% (998)	4.6% (115)	8.3% (115)

Note: ESS = Earth and Space Science; LS = Life Science; and PS = Physical Science.

Table ES4. Experts' Science Practice Ratings by Grade and Domain

Grade Level	Domain	ISP % (N)	USP % (N)	USI % (N)	UTD % (N)
4	ESS	59.2% (109)	23.9% (44)	12.5% (23)	4.3% (8)
4	LS	54.3% (102)	34% (64)	9% (17)	2.7% (5)
4	PS	49.5% (105)	23.6% (50)	18.4% (39)	8.5% (18)
4	*All*	54.1% (316)	27.1% (158)	13.5% (79)	5.3% (31)
8	ESS	56.6% (232)	40.2% (165)	2% (8)	1.2% (5)
8	LS	53.1% (242)	44.5% (203)	1.3% (6)	1.1% (5)
8	PS	52.6% (249)	38.3% (181)	8.7% (41)	0.4% (2)
8	*All*	54.0% (723)	41.0% (549)	4.1% (55)	0.9% (12)
12	ESS	24.9% (61)	56.3% (138)	18.8% (46)	0.0% (0)
12	LS	28.8% (101)	57.5% (202)	12.0% (42)	1.7% (6)
12	PS	31.3% (147)	42.6% (200)	22.1% (104)	4.0% (19)
12	*All*	29.0% (309)	50.7% (540)	18.0% (192)	2.3% (25)

Notes: ISP= Identifying Science Principles; USP= Using Science Principles; USI= Using Scientific Inquiry; UTD= Using Technological Design; 53 grade 4 standards, 177 grade 8 standards, and 314 grade 12 standards were not matched to any practices.

Conclusions

1. **When examining the content covered by the full set of states' science standards (with any NGSS performance expectations removed), there are many state statements that do not overlap in content with any NAEP statement.**
   - At grade 4, 31% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.
   - At grade 8, 32% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.
   - At grade 12, 55% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.

2. **Considering only the state content statements that the experts reviewed, all NAEP statements at least partially overlap in content with at least one state statement. In most cases, NAEP statements overlap in content with multiple state statements. Finally, in some cases, NAEP content statements are fully reflected in a combination of multiple state content statements.**
   - For each NAEP content statement HumRRO identified multiple state content statements with overlapping content. Review by external experts verified content overlap with at least one of these pairings for each NAEP content statement.
   - Experts noted that there were instances where a combination of state content statements would fully cover the content in a NAEP content statement.

3. **Experts rated the least amount of content overlap between NAEP and states' standards at grade 12.**
   - Overall, at grade 12, 19% of state content statements reviewed by expert panelists were rated as having no content overlap with a NAEP content statement.

4. **As with the NAEP-to-NGSS comparison, experts rated the least amount of overlap in content between NAEP and states' standard for the Physical Science domain, especially at grades 8 and 12.**
   - At grade 8, 9% of state Physical Science content statements reviewed by expert panelists were rated as not overlapping a NAEP content statement.
   - At grade 12, 25% of state Physical Science content statements reviewed by expert panelists were rated as not overlapping a NAEP content statement.

5. **Science experts identified the grades 4 and 8 state content statements to most frequently reflect NAEP's Identifying Science Practices and the grade 12 state content statements to most frequently reflect NAEP's Using Science Practices. The experts least frequently identified the states' content statements to reflect NAEP's Using Technological Design.**

   - At grades 4 and 8, 54% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's *Identifying Science Practices.*
   - At grade 12, 51% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's *Using Science Practices.*
   - Across the grade levels, between 1% and 5% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's *Using Technological Design.*

6. **Science experts noted that states whose standards are based on the NRC K–12 Science Framework have more in common with NAEP that states whose standards are not based on the framework.**

   - Consensus statements developed by both the grade 8 and grade 12 expert panels included assertions that they observed more content overlap between NAEP and the science standards of states who based their standards on the NRC K–12 Science Framework.

Comparative Analysis of the NAEP Science Framework and State Science Standards

Introduction

The purpose of this study was to compare the NAEP Science Framework to state science content standards, other than the Next Generation Science Standards (NGSS). Results of this research will inform the National Assessment Governing Board's (Governing Board) decision regarding whether and how the NAEP Science Framework may need to be updated.

We completed six major tasks to conduct the comparative analysis:

- Identify status of state adoption of NGSS
- Collect state science standards
- Identify and select science content experts
- Develop review processes and procedures
- Conduct science standards review
- Document and report review findings

Background

The NAEP Science Framework was last updated in 2005, and it was first implemented for the 2009 NAEP Science Assessment (National Assessment Governing Board, 2019). Principle 3 of the Governing Board's Framework Development Policy (2018) states "[r]eviews of existing frameworks shall determine whether an update is needed to continue valid and reliable measurement of the content and cognitive processes reflected in evolving expectations of students" (pg. 6). The policy notes that frameworks will be reviewed at least every 10 years, with more frequent reviews as needed. Given the time that has elapsed since the NAEP Science Framework was adopted by the Governing Board, the science framework is due for review. Since preparation of the 2009 NAEP Science Framework, understanding of how students think about and learn science concepts has changed. Of specific importance, the National Research Council (NRC) developed the Framework for K–12 Science Education (NRC, 2012) and the NGSS were released in 2013.

To begin the review process of the science framework the National Center for Education Statistics (NCES) commissioned a comparison of the NAEP Science Framework to the NGSS (see Neidorf et al., 2016). The current study complements the Neidorf et al. (2016) study by comparing the NAEP Science Framework to state science standards other than the NGSS. The findings of this study will contribute to the review of the NAEP Science Framework to determine whether an update is needed to meet the changes in science education that have occurred in the decade since the current NAEP Science Framework was adopted in 2005.

Methods

Our methodological approach drew from prior experience conducting standards-to-standards alignment studies (e.g., Koger, Deatz, Lozzi, & Furr, 2006; Dickinson, et al., 2014) and the processes and procedures employed for a similar review of the NAEP Mathematics Framework.

Our ultimate goal was to convene experts to review and compare the overlap of content between NAEP and state content statements, other than the NGSS. This comparison methodology was also used in a similar study that compared the NAEP Science Framework to the NGSS (Neidorf et al., 2016). This previous study involved a simple one-to-one comparison of two sets of content, while the current study compared one set of content (i.e., NAEP content statements) to multiple sets of content that varied in size and scope (i.e., 31 sets of state content statements). As a precursor, the current study required a process for evaluating state content standards to determine if and how a state should be included in the study.

Our first step involved identifying the state science content statements that should be compared to the content statements in the NAEP Science Framework. Because we did not want to duplicate efforts from the previous NAEP-NGSS comparison, we identified states that had adopted the NGSS and excluded them from the present study. Based on the National Science Teaching Association (NSTA), 20 states[1] and the District of Columbia have fully adopted the NGSS while six states have developed their own science standards[2]. The NSTA lists 24 states with science standards based on the NRC Framework, which we refer to as partial adopters of the NGSS.[3] Although the NSTA categorizes West Virginia as a partial NGSS adopter, this state's content statements (a) do not include key features of the NGSS such as cross-cutting concepts, scientific and engineering practices, or the three-dimensional nature of the NGSS standards; and (b) include the NGSS Disciplinary Core Ideas as well as other concepts not included in the NGSS. Based on these differences, we identified West Virginia as a non-NGSS adopter for purposes of this study.

Given the goal of the current study, our next step involved removing any NGSS content from the content statements of the states that have partially adopted the NGSS. We note that, even after removing any NGSS content from statements of the partial NGSS adopting states, a very large pool of science content remained. Thus, we took additional steps to further confirm the state science content statements. The additional steps helped strike a balance between including a manageable number of statements while still having the experts review as much non-NGSS content as possible.

After identifying the science content to be reviewed, we developed a process for experts to evaluate the overlap between the NAEP and states' sets of science content. To mirror prior approaches to standards-to-standards alignment (including the NAEP-to-NGSS comparison), we wanted experts in the current study to compare individual content statements. Such an approach ensures that experts closely review the content. It also allowed us to quantify the

[1] Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maine, Maryland, Michigan, Nevada, New Hampshire, New Jersey, New Mexico, Oregon, Rhode Island, Vermont, and Washington

[2] Florida, North Carolina, Ohio, Pennsylvania, Texas, and Virginia.

[3] Alabama, Alaska, Arizona, Colorado, Department of Defense Education Activity, Georgia, Idaho, Indiana, Louisiana, Massachusetts, Minnesota, Mississippi, Missouri, Montana, Nebraska, New York, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Utah, West Virginia, Wisconsin, and Wyoming.

amount of content overlap, as well as to quantify the extent to which states' content standards reflect similar science practices compared with NAEP.

We wanted the review for the current study to focus on content "overlap" rather than content "alignment" because the NAEP Science Framework and state science content standards were not developed with an intention of alignment. Though the NAEP Frameworks were informed by state content standards and state standards may have taken the NAEP frameworks into account during their development, a high degree of alignment was not necessarily expected. Thinking in terms of overlap best informed the extent to which states were outlining content expectations beyond what is reflected in the NAEP Science Framework.

As noted earlier, a major purpose of this study was to inform decisions around updates to the NAEP Science Framework. Thus, we collected qualitative feedback from experts regarding key ways that state science content standards differed from the NAEP Science Framework. The final component of our methodology integrated notes and other qualitative comments provided by the experts when developing consensus statements. The qualitative comments provided a summary evaluation of substantive key differences between the NAEP and state science content statements.

The remainder of this section describes the content standards compared, the processes of collecting and compiling the states' science content statements, and the process of gathering experts' judgments about the overlap in science content between NAEP and states' standards.

NAEP Science Framework

The NAEP Science Framework outlines the content that is to be assessed by the National Assessment of Educational Progress (NAEP) Science Assessment. Results from the NAEP Science Assessment inform the nation on its progress toward the goal of scientific literacy for all students. The NAEP Science Framework is intended to inform assessment development but does not "advocate for a particular approach to instruction" or "represent the entire range of science content and skills" (National Assessment Governing Board, 2014; p. ix).

Within the framework, NAEP science content statements are organized into three content domains: Physical Science, Life Science, and Earth and Space Sciences. These content statements "are derived from National Standards and Benchmarks and are informed by international frameworks and state standards" (National Assessment Governing Board, 2014; p. 13). Additionally, the NAEP Science Framework outlines the following four science practices:

- Identifying Science Principles (ISPs)
- Using Science Principles (USPs)
- Using Scientific Inquiry (USIs)
- Using Technological Design (UTDs)

The framework intends the NAEP science content statements and science practices be integrated to develop performance expectations that guide assessment development. The NAEP Science Framework provides guidance and examples for how content and practices may be integrated without specifying performance expectations for all combinations of content and practice.

Table 1 presents the distribution of NAEP content statements by grade level across the three content domains. At the three grade levels assessed by NAEP, the largest percentage of content statements are from the Physical Science domain.

Table 1. Number of NAEP Content Statements Per Grade Level and Domain

Grade Level	Domain	Number	Percentage
4	Earth and Space Sciences	11	33.3%
4	Life Science	7	21.2%
4	Physical Science	15	45.5%
Total Grade 4		33	100%
8	Earth and Space Sciences	15	34.9%
8	Life Science	12	27.9%
8	Physical Science	16	37.2%
Total Grade 8		43	100%
12	Earth and Space Sciences	13	26.5%
12	Life Science	13	26.5%
12	Physical Science	23	46.9%
Total Grade 12		49	100%

State Science Standards

In their science standards, state boards of education outline the knowledge, skills, and abilities that students in their state need to develop through their K–12 education to ultimately graduate from high school prepared for postsecondary educational and occupational opportunities. The science standards are intended to guide science assessment in the state, as well as related curriculum, instruction, and educator professional development. State standards provide a road map for what should be taught, but they do not dictate how content should be taught. Given their multi-purpose character, state content standards may be broader and deeper in scope than the NAEP frameworks.

Until recent years, each state developed its own science standards. Following publication of the NGSS, several states have chosen to formally adopt the NGSS to represent the science content required for their students to learn. Other states have not formally adopted the entirety of the NGSS, but instead have developed their own science standards that are similar to the NGSS and based on the National Research Council's (NRCs') Framework for Framework K–12 Science Education. In several cases, the commonalities of these states' standards with the NGSS are apparent, whereas in other cases the commonalities are less pronounced. A relatively small number of states have developed their own science standards that are clearly not related to the NGSS (e.g., are not three dimensional) or based on the NRC's framework.

Standards Collection Process

When collecting the states' science standards, we first verified whether a state had adopted the NGSS. We used reports from third parties that described the status of each state's adoption of NGSS, which we then confirmed by examining the state's education department websites. The description from these websites was used to inform the decision on whether the state had fully adopted or only partially adopted the NGSS. We defined a partial adopter as a state that used some or all the overarching NGSS three-dimensional structure, but added, removed, or redefined key elements. Table 2 presents the states classified for the current study as non-NGSS and partial NGSS adopters. For reference, full adopters are also listed.

Table 2. Non-NGSS, Partial NGSS, and Full NGSS Adopting States

Non-NGSS Adopting States	Partial NGSS Adopting States	Full NGSS Adopting States
Florida	Alaska	Arkansas
North Carolina	Alabama	California
Ohio	Arizona	Connecticut
Pennsylvania	Colorado	Delaware
Texas	Department of Defense Education Activity (DoDEA)	District of Columbia
Virginia	Georgia	Hawaii
West Virginia	Idaho	Illinois
	Indiana	Iowa
	Louisiana	Kansas
	Massachusetts	Kentucky
	Minnesota	Maine
	Missouri	Maryland
	Mississippi	Michigan
	Montana	Nevada
	North Dakota	New Hampshire
	Nebraska	New Jersey
	New York	New Mexico
	Oklahoma	Oregon
	South Carolina	Rhode Island
	South Dakota	Vermont
	Tennessee	Washington
	Utah	
	Wisconsin	
	Wyoming	

After we determined the states' NGSS adoption status (NGSS adopter, partial adopter, or non-NGSS state), we searched states' education department websites for their published science standards. We discovered at this stage that some states were in the process of updating their standards; that is, some states had developed new standards but had not yet fully implemented them in all districts or in all grades. The partial adopting states of Colorado, Minnesota, Oklahoma, and Wyoming fell into this category, as did the non-NGSS adopting state of Virginia. We consulted with the Governing Board and agreed to use the newest standards for these states, even though they had not been fully implemented by the 2019–20 school year. The structure of each non-NGSS and partial NGSS state's science content standards is presented in Appendix A.

Almost all states had their standards available in Adobe Acrobat and/or Microsoft Word formats. Some states included their science standards for all grades (K–12) in a single document; other states had the standards in separate grade-level documents or by for categories of grades (e.g., K–5, 6–8, and 9–12). Most of the states' standards documents included an introductory section that outlined the standards' framework and/or philosophy, which allowed us to determine (a) the similarity of the state's overarching standards structure to that of the NGSS and (b) notable differences between the state's standards and the NGSS. For standards documents without this summary information, we searched the education department websites for framework descriptions or looked at the individual standards themselves to extrapolate the structure used to inform them. We tracked this information in a spreadsheet. As an additional step for the non-NGSS adopters, we separated the individual elements of the NGSS' three dimensions (e.g., cross cutting content) and identified whether each non-NGSS state's standards included any similar elements.

Although states vary in how they organize and present their science content, states typically organize their science content standards around (a) the three major science domains (earth and space sciences, life science, physical science); (b) a series of subdomains within the major domains; and (c) a series of measurable content statements. We used the content statements as the unit of analysis for this study.

State science assessments typically include content from the tested grade level as well as that from preceding grade levels; thus, we followed a similar logic for the content to compare in this study. Including content for grades that preceded the target grade ensured the comparison did not omit state content assessed at each NAEP grade level. We included state content statements from grades 3 and 4 for the grade 4 NAEP content and state content comparison and content from grades 5–8 for the grade 8 NAEP content and state content comparison.[4] The grade 12 NAEP comparison included state content from grades 9–12 in some states, though some states organize their high school content by course rather than grade level. Appendix B presents the grade 12 science standard domains for each state included in the study and the domains we used for the standards review. We based selection of state high school science standards on the domains that most closely matched the three NAEP domains. When multiple standards matched a content area, we used high school graduation requirement information to identify the standards that most students would have the opportunity to learn, such as selecting from Biology I and Biology II or Physical Science, Chemistry, and Physics (see Appendix C).

Standards Compilation Process

The overall standards collection process yielded a very large set of content statements, many of which included content beyond the three major science domains of Physical Science, Life Science, and Earth and Space Sciences reflected in the NAEP content statements. Many states included content statements that addressed multiple content domains simultaneously (e.g., Nature of Science, Science Literacy). Some states also included grade level standards that focused on Engineering and Technology or Environmental Science. Counts of the initial number of compiled state content statements are presented in Appendix D.

Because content categories other than the three major science domains were not consistent across states, the current comparative analysis focused only on content from the Physical Science, Life Science, and Earth and Space Sciences domains. However, this still yielded too

[4] DoDEA uses NGSS for grades 6-12. So, only grade 5 statements from DoDEA were compared to grade 8 NAEP content statements.

large a number of state content statements, many of which were redundant across states and that reflected a pool of content that would be unmanageable or too burdensome for the experts to review within the designated timeframe for the current study. Therefore, we took additional steps to reduce the redundancy across the states' content statements.

We entered each state's content statements into their own tabs (by state) in an Excel file. These tabs were then read into a text comparison and analysis program to identify content statements across states that were exactly the same. This text comparison and analysis program assigned "word embedding" values to every word in every content statement. These word embeddings were based on a list of words with pre-calculated similarity scores that were applied to pairs of content statements to determine how semantically similar they were. The text comparison and analysis program produced a cosine similarity value for each pair of content statements. Higher cosine similarity values indicated that content statements were similar to one another. We describe slightly different next steps for non-NGSS and partial NGSS states in the following two paragraphs.

In addition to entering the state content statements into Excel, we also entered the NAEP content statements into a separate Excel file to facilitate identifying content redundancy and similarity between the state and NAEP content statements. Each non-NGSS state's content statements were compared to one another, as well as to the NAEP content statements. Using the aforementioned text comparison and analysis program, we used a cosine similarity value of .90 or higher to indicate that a state content statement was a duplicate of another state content statement. We used a cosine similarity value of .70 as an indicator of substantial similarity between state content statements and NAEP content statements. Any state content statements that had a cosine value of .70 or higher when compared to a NAEP content statement were considered to overlap in content with that NAEP statement. This yielded (a) one or more state statements that had at least some content that overlapped with content in a NAEP statement, (b) state content statements that had no content that overlapped with any NAEP statement and, in some cases, (c) NAEP statements that had no content that overlapped with any state statements.

We used a similar process to examine the similarity of the partial-NGSS state statements, with one additional step. For the partial-NGSS states, we also compared the state standard to the NGSS performance expectations (PEs) to identify and remove any NGSS content from the partial NGSS-state content statements. We used a cosine value of .90 or higher in our matching algorithm to indicate that a state content statement was a duplicate of an NGSS performance expectation. In several cases, we discovered that partial-NGSS states' content standards consisted primarily of NGSS PEs, though the state indicated it did not fully adopt the NGSS. Some states that were categorized as partially adopting the NGSS contributed a relatively small number of content statements to the overall pool of non-NGSS state content statements because their standards closely matched the NGSS. In some partial-NGSS states, the major difference between the NGSS and state standards was to delete selected NGSS PEs. Several states adopted the NGSS with added content statements related to the state's local context (e.g, addition of examples of science principles in an Alaskan context, inclusion of the ocean shore zone in South Carolina).

HumRRO staff then conducted a manual examination of all state content statements that had not been identified from the word embedding coding as a duplicate of an NGSS PE. HumRRO staff with science content backgrounds reviewed these statements to ensure there was indeed overlap of content with the NAEP statements or duplication of an NGSS PE.

Next, HumRRO staff with science content backgrounds reviewed the remaining state content statements that had not been identified via the automated process as having content overlap with NAEP. Two HumRRO staff independently reviewed each state content statement and attempted to identify at least one NAEP content statement with which the state content statement overlapped. Each of these ratings was color coded, green if the NAEP content statement was clearly related to the state content statement or yellow if the NAEP content statement was somewhat related to the state content statement. Any state content statement for which an overlapping NAEP content statement could not be identified was color coded red. These ratings were then adjudicated to determine which state content statements would be included in the expert panel rating process.

We included for the experts' review all the state content statements that had been identified through HumRRO's automated or manual process as either clearly or somewhat related to a NAEP content statement (i.e., color coded green or yellow). In this regard, **we took a liberal approach to identifying overlapping state and NAEP content for the purposes of the expert panel review to ensure the experts reviewed as much of the state content as possible while reducing the burden of reviewing content that was clearly unrelated or duplicative across state standards**. Although expert rating forms included only the state content statements that we believed overlapped with NAEP statements, experts were provided electronic versions of each state's full standards document, which provided them with access to the full set of state content statements.

To create a list of statements across states that included as little redundancy as possible, we identified standards that were duplicated across states or that were very similar in terms of the content and practice contained therein. We believed such a list would facilitate efficient as well as well as accurate ratings. For any word-for-word duplicates, we presented only one statement to be rated but noted all states that included that same standard. For content statements that were very similar, we presented the similar statements next to the statement the experts rated and informed the experts that their rating for that statement would also be applied to each similar statement. If experts did not agree with the level of similarity among any of these statements, they were instructed to provide notes and enter alternate ratings in their rating form. Results presented in the subsequent section treat all duplicate and similar content statements as if they were rated separately, thus more accurately reflecting the actual number of state content statements.

Table 3 summarizes the total number of content statements reviewed and the final number included in the expert panel review, by grade level and science domain. As seen, grade 12 had the largest difference in the number of statements the experts reviewed and rated. This is not surprising because the states vary widely in how their high school content is organized. In some states, high school science content standards are course specific. In these instances, we could easily identify the basic courses that corresponded to the three content domains (e.g., Biology 1, Chemistry 1, Physics 1). However, in a larger number of states, high school content was organized into the three broad domains, and as such included content from the most basic courses to the most advanced courses. Because advanced content often includes topics beyond what is measured by NAEP, it is reasonable that many of these state content statements would not overlap with NAEP content statements. States also varied widely in the number of statement content statements each contributed to the final pool of reviewed content statements. The number of content statements by grade, domain, and state are presented in Appendix E.

Table 3. Number of State Content Statements Per Domain and Grade

Grade	Domain	Total State Content Statements Reviewed	% State Content Statements Reviewed per Domain	# State Content Statements Presented to Experts	% State Content Statements Presented to Experts per Domain
4	Earth and Space Sciences	303	36.9%	209	33.3%
4	Life Science	239	29.1%	204	32.5%
4	Physical Science	279	34.0%	214	34.1%
Total Grade 4		821	*100%*	627	*76.4%*
8	Earth and Space Sciences	568	27.9%	462	30.5%
8	Life Science	696	34.2%	533	35.2%
8	Physical Science	770	37.9%	520	34.3%
Total Grade 8		2,034	*100%*	1,515	*74.4%*
12	Earth and Space Sciences	623	25.0%	295	21.4%
12	Life Science	794	31.8%	457	33.1%
12	Physical Science	1,078	43.2%	627	45.5%
Total Grade 12		2,495	*100%*	1,379	*55.2%*

Note: Number and percentage reviewed reflects all state content statements compiled from the non-NGSS and partial NGSS states. Number and percentage presented to experts reflect all state content statements that overlapped with a NAEP content statement based on HumRRO's review and were subsequently evaluated by the experts. Percentages presented in ***bold italics*** represent the percentage of the state content statements reviewed that were evaluated by experts.

Selecting Science Experts

Our method for collecting judgments about the overlap of content between NAEP and states' content statements involved three separate grade-level panels, one panel for each of the grades assessed by NAEP—grade 4, grade 8, and grade 12—with three experts participating in each panel. After an initial discussion with Governing Board staff about the necessary background and expertise, we compiled a list of 30 potential experts who (a) were familiar with the NGSS as well as multiple states' science standards, (b) possessed standards design and implementation experience, (c) had direct experience teaching science content, (d) had participated in national or multi-state science committees, and (e) represented diverse demographic characteristics. We presented this list of science experts to Governing Board staff and, through a series of discussions, we worked with Governing Board staff to identify and secure the participation of nine highly qualified experts to provide the requisite science content overlap ratings. Table 4 presents a summary of select background characteristics and targeted experience for the nine science experts who participated in the study.

Table 4. Summary of Experts' Characteristics and Experiences

Grade	Standards Design	Familiar w/ State Standards	Direct K–12 Classroom Experience	National/ Multi-State Committees	Region	Race	Gender
4	3/3	CA, NJ, NY	3/3	2/3	Northeast (2) West (1)	Black (1) White (2)	Female (2) Male (1)
8	1/3	AK, CT, IL, MI, NE, NJ, NY	2/3	3/3	Midwest (1) South (1) West (1)	Black (1) White (2)	Female (2) Male (1)
12	2/3	MA, TN, OR, 50 state science network[5]	2/3	2/3	Northeast (1) South (1) West (1)	Asian (1) White (2)	Female (2) Male (1)

Expert Judgments

In this section, we describe the process for collecting expert judgments of the extent of the overlap between NAEP and state content statements. Included are description of training, the rating process, and the adjudication process.

Training

We convened a virtual meeting via Microsoft Teams on September 24, 2020, to train all experts together on the review and rating process.[6] Prior to the meeting, we sent the experts read-ahead materials that described the background, purpose, and goals of the study; key study activities; and general information about the rating process. The training included expectations for reviewing and interpreting the paired NAEP-state content statements and familiarizing the experts with the rating forms and entering their ratings. However, the primary purpose as well as the majority of training time was devoted to experts participating in a calibration activity to ensure standard interpretation of the paired NAEP-state statements and application of the rating criteria.

The paired NAEP and state content statements served as the foundation of our expert training. Experts were trained to evaluate the amount of content overlap between the NAEP content statement and the state content statement that had been previously identified as overlapping via HumRRO's internal process. We emphasized that these ratings were different than traditional "alignment" ratings insofar as the NAEP and state content were not necessarily developed with alignment to one another in mind. Rather, the focus was on any overlap on the content reflected in each statement. We further emphasized that the focus should be on content overlap and not overlapping practices.

The calibration activity that composed the bulk of training included three examples; one example was completed for each of the three grades (i.e., grades 4, 8, and 12). For each example, experts reviewed a paired NAEP-state content statement and applied the criteria they had been trained to use to independently rate (shared via the chat function within the MS Teams app) (a) the level of overlap in content between the NAEP statement and state

[5] Formerly NGSS Network.
[6] One expert accepted the meeting invitation but was unable to attend. We trained this expert via a separate Microsoft Teams meeting on September 28, 2020.

statement and (b) the NAEP science practice(s) reflected in the state content statement. HumRRO staff facilitated a group discussion of the experts' independent ratings that highlighted appropriate interpretations of the paired NAEP and state statements as well as what constituted an appropriate rating justification.

Content Interpretation and Overlap Rating Criteria

The primary purpose of the current study was to gather information to inform whether the NAEP Science Framework should be revised and, if so, what revisions may be needed. Our study focused on the content covered by the science standards of states across the country and how that content may differ from the science content assessed by NAEP. We gathered this information primarily from experts' judgments regarding the extent to which there was overlap in the content covered by NAEP and states' standards. In this section, we describe how experts were trained to approach the rating process.

We instructed experts to treat the NAEP content statement as the "base" statement and to compare each state content statement to its paired NAEP statement to determine any content overlap. That is, the experts were to carefully review the NAEP statement and the state content statement, determine the essential content covered by each statement, and rate the level of content overlap between the two.

We defined essential content as the most important concepts presented in the statement and that fully captures the content that the statement intends to measure. To ensure calibration, the experts compared as a group several example content statements. This comparison generated discussion amongst the experts regarding what constituted essential content. The following is an example of paired NAEP content and state content statements that the experts compared and discussed:

- **NAEP Content Statement**: One way to change matter from one state to another and back again is by heating and cooling. (P4.6)
- **State Content Statement**: Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. (MO)

The experts were initially split as to whether these two statements were fully or partially overlapping in the science content they covered. Experts discussed what elements of each content statement were essential. In this example, although both content statements address the concepts of heating and cooling, the experts determined that the reversibility of changes is essential to the state content statement, but this essential content was not contained in the NAEP statement. Thus, for this example, the experts provided a rating of partial overlap for these NAEP-state content statements.

Based on their comparison of the NAEP and state content statements, experts determined if the essential content covered in the NAEP statement was fully covered, partially covered, or not covered at all by the state content statement. Experts provided a "full overlap" rating when all the essential content measured by the NAEP statement was also assessed by the state content statement. A rating of "partial overlap" thus indicated that the state statement contained the essential content covered by the NAEP statement, but also included some additional essential content that was not included in the NAEP statement. A "no overlap" rating was provided when there was no key content in the NAEP statement that was covered in the state statement (i.e., the NAEP and state statements essentially covered different content). Given our process for

reducing redundancy across the state statements and pairing NAEP and state statements, we expected the number of “no overlap” ratings would be minimal. Table 5 summarizes the three categories of content overlap ratings.

Table 5. Summary of Content Overlap Rating Categories

Rating	Definition
Full overlap	All essential content in the NAEP content statement is contained in the state content statement.
Partial overlap	Some essential content in the state content statement is not in the NAEP content statement.
No overlap	The key content measured by the two content statements is different.

We developed separate Excel workbooks for the experts to record their ratings. The workbooks were tailored to each grade while all presented the paired relevant NAEP-states’ statements by content domain across multiple worksheets. Each worksheet featured a single NAEP statement, along with all paired states’ content statements. The worksheets included a series of columns for the experts to enter their ratings of the (a) extent of content overlap between each paired NAEP-state content statement and (b) NAEP science practice(s) reflected in the state content statement. An example rating form is presented in Appendix F.

Experts had approximately 2–3 weeks to independently complete their assigned grade-level ratings. To facilitate this process, HumRRO created a unique Google Drive folder for each expert. Use of separate Google Drive folders allowed (a) the experts to complete their independent ratings, without access to other experts’ ratings and (b) HumRRO staff to monitor the experts’ work and progress towards completion. Each folder contained the appropriate grade-level rating form and supplemental materials, including those reviewed and discussed during training, which included the following (see Appendix F for sample supplemental materials):

- Detailed process instructions
- Content overlap ratings overview
- NAEP science practices overview
- Full NAEP Science Framework (PDF file)
- States’ full science standards document (PDF files)

To provide a forum to raise questions and engage in some discussion to further promote a common interpretation of content issues, HumRRO created a communications email thread. All rating folders and discussions among the experts were monitored by HumRRO staff to ensure ratings were completed independently.

HumRRO staff regularly monitored the progress of the experts as they completed their ratings and contacted them in the event of consistently aberrant ratings. Our monitoring was supported through the use of conditional formatting within the experts’ rating forms to highlight instances where experts were not in agreement. In instances where an individual expert consistently applied ratings that were non-adjacent to those of other experts (e.g., rated as 'no overlap' when other experts rated as 'full overlap') we sent a targeted email reminding the expert of the rating guidance and asking them to provide a rationale for select ratings. When there was no

consistent pattern of disagreement (i.e., no expert was consistently rating differently than the other experts), we flagged any discrepant ratings for the experts to discuss and adjudicate.

Science Practices Ratings

Because science content and science practices can be integrated in multiple ways to yield a variety of measurable performance expectations, the NAEP Science Framework presents content and practice separately. Further, the states vary in the ways their content statements incorporate both science content and practice. Given the difference in how NAEP and the states present and assimilate their science practices, we could not easily compare the overlap of science practice content comparisons. However, we were interested in the extent to which state science standards reflect science practices that ware similar to NAEP's. A secondary purpose of this study was thus to document the extent to which science practices outlined by NAEP are reflected in state science content standards.

Experts provided ratings of the primary NAEP science practice they believed was reflected in each state content statement. Unlike the content overlap ratings, this rating did not involve a comparison of paired NAEP and state content statements. Rather, the experts merely evaluated each state content statement in terms of the science practice indicated.

We trained experts to identify the NAEP science practice using the guidance presented in the NAEP Science Practices Overview support document, which contained definitions of each science practice as well as example performance expectations associated with each NAEP science practice. During calibration activities, experts discussed the distinctions between the science practices. As an example, the experts noted that Using Science Principles (USP) rather than Using Scientific Inquiry (USI) was a more appropriate practices for identify for the state content statement *Research invasive species and discuss their impact on ecosystems*. Their rationale was that the state content statement did not require validating or critiquing, but rather involved only explaining what was observed.

Adjudication

After all independent ratings were collected, HumRRO staff conducted preliminary analyses to identify areas where experts differed in their ratings. When two of three experts agreed, we recorded that majority rating as final. These preliminary analyses resulted in 66 discrepant ratings at grade 4, 70 discrepant ratings at grade 8, and 29 discrepant ratings at grade 12 that the experts needed to discuss and adjudicate.

We convened separate grade-level meetings via Microsoft Teams for experts to discuss and adjudicate the discrepant ratings (grades 4, 8, and 12). Because of limited expert availability and to accommodate a range of time zones across the experts' locations, we held 1–2 adjudication meetings per panel, with each meeting lasting 2–3 hours. Each meeting focused primarily on arbitrating instances where all three experts differed in their content overlap ratings and secondarily on instances where all three experts differed in their science practice ratings.

Prior to the adjudication meetings, we informed experts that a final step in the process involved developing consensus statements that summarize the panel's overall thoughts regarding the level of overlap in content at their assigned grade between NAEP and the state content statements the experts reviewed., We facilitated the development of these consensus statements to support interpretation of the content overlap ratings and to further inform decision making around modifications to the NAEP Science Framework. Consensus statements for each

grade consist of a paragraph addressing the overlap between NAEP and state content generally, and a paragraph addressing the content overlap within each domain, with a focus on content covered by states that is not covered by NAEP. Consensus statements are presented in the Results section of this report.

Results

All State Content Statements

This section presents the results based on all the state content statements reviewed. These results combine the determinations made by HumRRO of the state content statements that were not identified as overlapping any NAEP content statement with the experts' ratings.

Table 6 shows that for the grades 4 and 8 NAEP content statements, most state content statements were rated as partially or fully overlapping. Across the three science domains, more than one-third of state content statements were rated as fully overlapping a NAEP content statement. In other words, experts indicated that all the essential content in the NAEP statement was contained in the paired state statement. Just under one-third of grades 4 and 8 state content statements were rated as partially overlapping the NAEP content statement to which they were paired. This means that experts felt that although the key NAEP content was contained in the paired state content statement, the state content statement contained some other key content element that was not contained in the paired NAEP content statement. Similarly, **just under one-third of state content statements for grades 4 and 8 were rated as not overlapping with a NAEP content statement, meaning that experts felt there were no key content elements shared by the state content statement and the paired NAEP content statement**.

Compared to the other grades, grade 12, had the largest percentage of state content statements rated as not overlapping with a NAEP content statement. Recall this result includes the state content statements determined by HumRRO to be not overlapping HumRRO, which were not presented to the experts. As noted in a prior section of the report, **many states' high school science standards included advanced topics that were beyond the scope of the NAEP framework and thus, did not overlap with any NAEP content statement**.

Experts rated more than one-third of the grade 12 state content statements as partially overlapping their paired NAEP content statement, indicating that experts felt that although the key NAEP content was contained in the paired state content statement, the state content statement contained some other key content element that was not contained in the paired NAEP content statement. Roughly 5% of the grade 12 state content statements were rated as fully overlapping the paired NAEP content statement, indicating that experts felt these state content statements covered all the essential content contained in their paired NAEP content statement.

Table 6. Content Overlap Ratings by Grade and Domain

Grade	Domain	No Overlap % (N)	Partial Overlap % (N)	Full Overlap % (N)
4	ESS	37.0% (112)	27.4% (83)	35.6% (108)
4	LS	22.6% (54)	34.7% (83)	42.7% (102)
4	PS	31.9% (89)	28.0% (78)	40.1% (112)
Total Grade 4		*31.1%* (255)	*29.7%* (244)	*39.2%* (322)
8	ESS	25.4% (144)	34.3% (195)	40.3% (229)
8	LS	29.5% (205)	39.8% (277)	30.7% (214)
8	PS	38.6% (297)	22.7% (175)	38.7% (298)
Total /Grade 8		*31.8%* (646)	*31.8%* (647)	*36.4%* (741)
12	ESS	58.6% (365)	36.0% (224)	5.5% (34)
12	LS	51.4% (408)	45.3% (360)	3.3% (26)
12	PS	56.5% (609)	38.4% (414)	5.1% (55)
Total Grade 12		*55.4%* (1,382)	*40.0%* (998)	*4.6%* (115)

Note: Percentages in *italics* represent column percentages (i.e., the percent of standards rated 0, 1, or 2 regardless of domain). Percentages in normal text represent row percentages (i.e., the percent of standards rated 0, 1, and 2 within a domain).

State Content Statements Rated by Experts

This section presents results based solely on ratings made by the expert. These results do not include the states' content statements determined by HumRRO to be not overlapping with NAEP content, which thus removed prior to experts making their ratings.

Across the three grade levels, experts rated most state content statements they reviewed as partially or fully overlapping content with the paired NAEP statement. In grades 4 and 8, a higher percentage of state content statements tended to be rated as fully overlapping. One exception to that pattern was grade 8 Life Science, in which experts rated a higher percentage of state content statements as partially overlapping content with the paired NAEP statement.

Across the grade levels and domains, experts rated between 8% (grade 8 Earth and Space Sciences) and 25% (grade 12 Physical Science) of content statements they reviewed as not overlapping the paired NAEP content statement. Also, across the grade levels and domains, they rated between 34% (grade 8 Physical Science) and 79% (grade 12 Life Science) of the content statements as partially overlapping the paired NAEP content statement. Finally, across the grade levels and domains, the experts rated between 6% (grade 12 Life Science) and 57% (grade 8 Physical Science) of the content statements they reviewed as fully overlapping the paired NAEP content statement. While similar to Table 6, Table 7 presents the content overlap ratings made by experts, but it does not include any state statements that HumRRO determined do not overlap in content with a NAEP statement.

Table 7. Experts' Content Overlap Ratings by Grade and Domain

Grade	Domain	No Overlap % (N)	Partial Overlap % (N)	Full Overlap % (N)
4	ESS	8.6% (18)	39.7% (83)	51.7% (108)
4	LS	9.3% (19)	40.7% (83)	50% (102)
4	PS	11.2% (24)	36.4% (78)	52.3% (112)
4	*All*	9.7% (61)	38.9% (244)	51.4% (322)
8	ESS	8.2% (38)	42.2% (195)	49.6% (229)
8	LS	7.9% (42)	52% (277)	40.2% (214)
8	PS	9% (47)	33.7% (175)	57.3% (298)
8	*All*	8.4% (127)	42.7% (647)	48.9% (741)
12	ESS	12.5% (37)	75.9% (224)	11.5% (34)
12	LS	15.5% (71)	78.8% (360)	5.7% (26)
12	PS	25.2% (158)	66% (414)	8.8% (55)
12	*All*	19.3% (266)	72.4% (998)	8.3% (115)

Note: Percentages in *italics* represent column percentages (i.e., the percent of standards rated 0, 1, or 2 regardless of domain). Percentages in normal text represent row percentages (i.e., the percent of standards rated 0, 1, and 2 within a domain).

All NAEP statements reviewed by experts were rated as overlapping in content to some degree with at least one state statement. Most state content statements that were determined by HumRRO to be at least partially overlapping in content with a NAEP statement (and thus seen by experts) were rated by the experts as partially or fully overlapping. The exception to this finding was at grade 12. HumRRO determined several grade 12 NAEP statements as overlapping in content with one or more state statements while the experts rated these paired statements as not having any overlap in content. This was likely a function of our process, in which we tended to include state content statements we questioned in overlapping content or believed only vaguely related to a NAEP content statement. We believe this tendency in our process had a more pronounced effect at grade 12, where state content statements often focused on very narrow, advanced topics. NAEP content statements and the number of state statements that expert panelists rated as not overlapping, partially overlapping, or fully overlapping with each NAEP content statement are presented in Appendix G.

Table 8 presents experts' consensus ratings about the NAEP science practices reflected in the state content statements they reviewed. Across the three NAEP grade levels, experts rated most state content statements as Identifying or Using Science Principles. **In grades 4 and 8, experts rated the largest percentage of state content statements as Identifying Science Principles, whereas experts rated the largest percentage in grade 12 state content statements as Using Science Principles.** This pattern of ratings makes sense considering that students at higher grade levels may be expected to engage in more application of science principles and practices. Also, it is not surprising that **relatively few state content statements were rated as Using Technological Design** given that we focused on Physical Science, Life, Science, and Earth and Space Sciences and did not include states' Engineering and Technology standards that were classified separately from science standards in the analysis.

Table 8. Experts' Science Practice Ratings by Grade and Domain

Grade Level	Domain	ISP % (N)	USP % (N)	USI % (N)	UTD % (N)
4	ESS	59.2% (109)	23.9% (44)	12.5% (23)	4.3% (8)
4	LS	54.3% (102)	34% (64)	9% (17)	2.7% (5)
4	PS	49.5% (105)	23.6% (50)	18.4% (39)	8.5% (18)
4	*All*	54.1% (316)	27.1% (158)	13.5% (79)	5.3% (31)
8	ESS	56.6% (232)	40.2% (165)	2% (8)	1.2% (5)
8	LS	53.1% (242)	44.5% (203)	1.3% (6)	1.1% (5)
8	PS	52.6% (249)	38.3% (181)	8.7% (41)	0.4% (2)
8	*All*	54.0% (723)	41.0% (549)	4.1% (55)	0.9% (12)
12	ESS	24.9% (61)	56.3% (138)	18.8% (46)	0.0% (0)
12	LS	28.8% (101)	57.5% (202)	12.0% (42)	1.7% (6)
12	PS	31.3% (147)	42.6% (200)	22.1% (104)	4.0% (19)
12	*All*	29.0% (309)	50.7% (540)	18.0% (192)	2.3% (25)

Notes: ISP= Identifying Science Principles; USP= Using Science Principles; USI= Using Scientific Inquiry; UTD= Using Technological Design; 53 grade 4 standards, 177 grade 8 standards, and 314 grade 12 standards were not matched to any practices.

Interrater Reliability

Although final study results are based on experts' final consensus (or majority) ratings, we examined the reliability of experts' initial independent ratings to gain insight into their shared understanding of the rating task. To quantify the interrater reliability of ratings of content overlap, we calculated Gwet's AC2 statistic, which supports ordinal level categories and has been found to be less influenced by marginal values than the traditionally reported Cohen's kappa (Warrens, 2010). To quantify the interrater reliability of ratings of science practices, we calculated Fleiss' kappa, which supports nominal level categories (Fleiss,1971).

Although there are many approaches to calculating interrater reliability, there are relatively few guidelines for interpreting the different statistics. Table 9 provides the calculated statistics, along with descriptions of the degree of agreement, using general guidelines outlined by Landis and Koch (1977) for interpreting kappa statistics. The grade 4 panel's ratings demonstrated fair to moderate level of expert agreement on the content overlap and science practice ratings, respectively. The grade 8 panel's ratings demonstrated a moderate level of expert agreement on content overlap, but only slight agreement about the science practices. The grade 12 panel's ratings demonstrated substantial expert agreement on content overlap, and fair agreement on science practices.

Impacting the level of expert agreement on the science practice ratings is the nature of the rating categories. There is some amount of overlap among the different categories of science practice, which contributes to rater disagreement. As stated in the NAEP Science Framework, "practice categories themselves are not distinct" (National Assessment Governing Board, 2014; p. 78). All results are based on majority (at least two expert panelists in agreement based on their independent ratings) or consensus (expert panelists discussed rating discrepancies and came to agreement) ratings.

Table 9. Interrater Reliability Statistics

Grade Panel	Content Overlap Ratings	Science Practice Ratings
	Weighted k (AC2)	Fleiss' k
4	.34 (Fair)	.44 (Moderate)
8	.57 (Moderate)	.19 (Slight)
12	.60 (Substantial)	.36 (Fair)

The reliability of the content overlap ratings is arguably of more interest, as the major goal of this study is to identify the similarities and differences between content of the NAEP and states' statements. In Table 10, we present the number and percentage of content overlap ratings that required adjudication. As seen, all three panels initially disagreed on the degree of content overlap between a NAEP statement and a state statement. Table 10 shows a total of 13% of NAEP-state statement ratings at grade 4 required adjudication, whereas only 2.4% of the NAEP-state statements at grade 12 required adjudication.

Table 10. Number of Content Overlap Ratings Requiring Adjudication

Grade Level Panel	Domain	N Adjudicated	Total N	% Adjudicated
4	Earth and Space Science	16	172	9.3%
4	Life Science	26	167	15.6%
4	Physical Science	24	167	14.4%
Total Grade 4		66	506	13.0%
8	Earth and Space Science	14	370	3.8%
8	Life Science	22	453	4.9%
8	Physical Science	34	482	7.1%
Total Grade 8		70	1305	5.4%
12	Earth and Space Science	9	250	3.6%
12	Life Science	9	400	2.3%
12	Physical Science	11	536	2.1%
Total Grade 12		29	1186	2.4%

Workshop Quality

Following the adjudication meetings, experts completed a debriefing survey that included items about the experts' perceptions regarding the quality of rater training and associated materials, and fair and appropriate rating process. Eight of the nine experts completed the survey, for a response rate of 88.9%. Across the three panels, experts tended to report positive perceptions of the kickoff meeting/rater training being useful (100%) and the process for determining final ratings was fair (100%). Although most experts (87.5%) perceived the support documents were clear, understandable, and useful (87.5%), one expert (12.5%) provided a negative rating of the quality of the support documents, indicating they would have preferred more advanced preparation prior to completing their ratings. Experts reported HumRRO staff was responsive to their questions when completing their ratings (100%). Two of the eight responding experts (25%) disagreed with the appropriateness of the comparison method used. These experts'

comments indicated it was difficult to compare the very specifically written state content statements with the more generally written NAEP content statements. Two of the eight responding experts (25%) indicated the electronic rating forms were not easy to use. Six experts (75%) perceived the method for comparing the paired NAEP-state statements was appropriate, while two experts (25%) disagreed this method was appropriate. Table 11 summarizes results from the debriefing survey.

Table 11. Debriefing Survey Results

Statement	% Strongly Disagree	% Disagree	% Agree	% Strongly Agree
The virtual kickoff meeting/training provided useful information about the review process.	0%	0%	75%	25%
The support documents provided were clear, understandable, and useful in performing the review steps.	0%	12.5%	75%	12.5%
HumRRO staff was responsive to questions during the review process.	0%	0%	12.5%	87.5%
The electronic rating forms were easy to use.	0%	25%	50%	25%
The adjudication process for determining final ratings was conducted fairly.	0%	0%	25%	75%
Overall, the method used for comparing the NAEP content statements to the state content statements was appropriate.	0%	25%	50%	25%

Consensus Statements

In this section, we present the consensus statements produced by each panel. Recall the consensus statements summarize each panel's overall thoughts regarding the level of overlap in content between the NAEP and the state content statements. As noted below, each panel provided overall and domain-specific statements.

Grade 4 Consensus Statements

General

NAEP science content statements are broad, and differences exist between states that have standards guided by the National Research Council (NRC) K-12 Science Framework compared to states that did not, as well as states that have not yet revised their standards. State standards required a higher level of performance than the NAEP Science Framework, asking students to perform tasks rather than simply evaluate the accuracy of declarative statements.

Life Science

The NAEP Life Sciences standards provide a broad overview of several core concepts. The state content statements are similar with some overlap to content in the NAEP statements, but

there are notable differences between the NAEP and state content statements, with important content missing in the NAEP content statements that is present in several state content statements. For example, several states' standards include the structure and function of organisms, food chains, webs, and pyramids, and the flow of matter and energy in the ecosystem and the impact on the environment while NAEP statements do not. The NAEP Life Science statements could expand on concepts of fossils, changing environments, and physical features, behaviors, and adaptions to the environment of invertebrates and vertebrates. Other key concepts included in some states' standards but not in the NAEP Life Science content statements are engineering and technology applications and scientific reasoning.

Physical Science

The NAEP Physical Science standards have some overlap with state standards but are generally dissimilar in content. There is content missing in the NAEP standards that is present in several state standards, including physical and chemical changes, such as the differences between solutions and mixtures, and an introduction to energy transfer, energy change, and, motion. Some states' standards also include content pertaining to simple machines, how light reflects from objects and is viewed or absorbed and technology and engineering applications whereas the NAEP statements do not include this content. Overall, the NAEP statements tend to be precise and focused on conceptual and procedural methods (e.g., reasoning, epistemic practices), while most of the states' standards are somewhat vague or focused on low level understandings of concepts or lower depths of knowledge.

Earth and Space Sciences

The NAEP Earth and Space Sciences content statements have some overlap with state content standards but are generally dissimilar in content. The states' standards tend to include content related to weather, climate, and the constant changing of Earth's surface and the rate of change (e.g., slow rates of weathering and erosion, rapid changes including landslides, volcanic eruptions, and earthquakes), while the NAEP statements do not include this content. Other key concepts included in the states' standards not covered in the NAEP Earth and Space Sciences statements include physical characteristics and attributes of rocks and minerals, fossils, renewable and non-renewable resources, layers of Earth's atmosphere, and the water cycle. Some states' Space Sciences standards include planetary characteristics and placement of objects and location in the solar system; the NAEP statements do not include this content. The NAEP statements do not include content related to the motions of the Earth, moon, and sun and changes visible in the night sky, including phases of the moon and position of stars, whereas states' standards tend to include this content. States' standards also focus on comparing characteristics of Earth with other planets in the solar system, but the NAEP statements do not cover this content. The NAEP Earth and Space Sciences do not include engineering and technology applications and scientific reasoning, whereas states' standards tend to include this content.

Grade 8 Consensus Statements

General

NAEP Science content statements are frequently vague, lack depth in some areas, and often do not require conceptual understanding since many NAEP statements are simple declarative statements. Since NGSS and NRC K-12 Science Framework-based assessments are three-dimensional, asking students to go beyond recognizing a scientific fact, **clear differences were**

seen between the states that have standards guided by the NRC K-12 Science Framework compared to states that have not yet revised their standards. Content coverage on NAEP was an issue, with broadly written statements likely leading to variation in interpretation. Students could conceivably fail to successfully answer NAEP items while being able to answer more complex NRC K-12 Science Framework-based assessment items, simply by lacking recall of facts, definitions, or vocabulary used in the NAEP item. This may lead to differences in implementation or perceived requirements. NAEP might consider stating what students would be expected to understand by the 8th grade or by the time they get to a particular content topic.

Life Science

Life Science has the strongest overlap between the NAEP content statements and state content statements. However, the NAEP Life Sciences content statements overall provide a broad overview but lack sufficient depth. The central differences are between the NRC K-12 Science Framework-based state standards and NAEP in terms of using science and engineering practices versus the NAEP practices. While the NAEP and state content were similar, some important state content statements were not included in the NAEP content statements. NAEP is not explicit about which organisms or processes should be focused on, including understanding the functions of the different parts of the cell, cell division, food chains, webs, and pyramids, and the flow of matter and energy between the organism and the environment. This flexibility could be advantageous or disadvantageous. The NAEP Framework could include a full statement of natural selection. It includes some components but not the idea that species traits can change over time as a consequence of naturally occurring variation, differential survival, and changing environments and that embryological structure can be used to show evolutionary relationships, as well as the importance of sexual and asexual reproduction. This is a central idea in biology and an understanding of how this mechanism leads to changes in traits in populations is important middle school Life Science content. Another missing topic is the issue of climate change – relevant assessments, as they do in the NRC K-12 Science Framework, might include chemical processes of carbon in the atmosphere, causes of climate change, and evidence of climate change. Other key concepts that could be expanded upon within the NAEP Life Science content statements are photosynthesis, respiration and transpiration, the molecular analysis of how matter is broken down in organisms, and the impact of humans on the biological world. Adding performance expectations and providing process examples would help with clarification of standards.

Physical Science

The NAEP Physical Science content statements incorporate a few important concepts spread out across the content topics, causing them to lack depth and breadth There is content missing in the NAEP contents statements that was present in several state standards that are important. This includes more content related to atoms as basic building blocks and investigating the subatomic structures of protons, neutrons, and electrons, the different states of matter (solid, liquid, gas) and how they relate to thermal energy and particle motion during phase changes. The NAEP Physical Science content statements could clarify the intended depth and breadth of students' knowledge of kinetic theory. Currently, there are several topics related to kinetic theory, but there is not a clear progression and some key ideas, such as an explanation of thermal energy transfer as transfer of kinetic energy of particles, are omitted from the NAEP content statements. NAEP lacks sufficient content to show students' understanding of different types of energy, waves, and the conservation of mass. Additionally, while there is a NAEP statement that light energy from the sun is a primary source in heating earth and "providing the

energy that results in wind, ocean currents and storms," there is no mechanistic model required of students that maps how the sun's energy results in climate or weather phenomena.

Earth and Space Sciences

The NAEP Earth and Space Sciences content statements are very broad and do not have the same depth of content coverage as some state standards. As a result, this leaves it up to the individual to infer the depth covered, processes inferred, and breadth of content to be covered. More content could be added to the NAEP statements on weather and climate, particularly with specific concepts related to understanding the mechanisms of transpiration, evaporation, condensation, precipitation, and the processes through which the energy from the sun results in global climate and weather patterns. Other key concepts that could be expanded within the NAEP Earth and Space Sciences content statements include the characteristics and placement of objects in the solar system, especially in relation to scale, location in the solar system, and relationship of the objects. Since many of the NAEP content statements are declarative statements, they read more like conclusions drawn from a chapter or unit. The NAEP Earth and Space Sciences content statements could be explicit about processes involved and include performance expectations as specific directives.

Grade 12 Consensus Statements

General

The states that used the NRC K-12 Science Framework and/or the Next Generation Science Standards as a reference to develop their state standards were rated as having more overlap with NAEP, including content and inclusion of practices. The states that did not use these two guiding documents, are more knowledge-based with older standards that have not been recently revised, and mostly entail fact based and low depth of knowledge (DOK) science standards that do not require students to incorporate or use the practices to explain phenomena and or plan and carry out scientific investigations. A big difference across the domains is the impact of integrating the science and engineering practices. This leads to many of the state standards being more explicit about relevant evidence, modelling, or even prediction and testing/experimenting. The broadness of the of topics of the NAEP Framework can lead to misconceptions of different concepts and variation in interpretation. The physical and life sciences have the highest amount of partial overlap between the state and NAEP content statements.

Life Science

Overall, the NAEP Life Science content statements have a lot of overlap in the broader conceptual scope, but there are differences in the level of detail. The states that used the NRC K-12 Science Framework and/or the Next Generation Science Standards as a reference to develop their state standards have more overlap with NAEP, including content and inclusion of practices. States that did not incorporate the NRC K-12 Framework or the NGSS into their standards are the least similar. States are typically more specific than NAEP and include performance expectations (integration of practices with concepts) rather than straight concepts. States tend to focus on process details around cellular processes and inheritance processes; NAEP does not. However, states are less direct in the treatment of evolution-related concepts. The NAEP standards could add a few specific concepts and ideas, including adding in more content related to cellular respiration, the cycling of matter and energy, or the relationship between photosynthesis and respiration. Other topics that would add depth to the coverage

include biodiversity, resilience, or succession, as well as more focus on the role of humans (including solutions).

Physical Science

There is a fair amount of overlap between the NAEP Physical Science content statements and the state content statements. Overall, states are more detailed than NAEP, and state content statements typically include more details which may not actually be expected in the NAEP statement. For example, the addition of waves in the NGSS Physical Science standards has been a significant change for states. However, in others, including NAEP content statements related to Newton's Laws, the state content statements tend to not distinguish different kinds of motion, except force. Additionally, there are discrepancies in information between NAEP and state content statements. For example, slight differences in how each describe the bonding of compounds and molecules is potentially confusing to students. Many state content statements are more focused on processes, details, and applications than NAEP.

Earth and Space Sciences

While the state Earth and Space Sciences content statements have a lot of overlap with NAEP in the broader conceptual scope they have the least overlap with the NAEP content statements. States are typically more specific than NAEP, and differences exist in the level of detail, especially those states with more traditional standards, or standards not reflective of NGSS. While some states include expectations regarding Astronomy, at the high school level, Space Science is given less emphasis in comparison to Biology, Chemistry, and Physics. More content could be added to the NAEP content statements regarding the application of analysis of different tectonic boundaries and geographic features, as well as a more detailed focus on density and radioactive decay. Additionally, a number of the states include weather as a complement to climate, especially in the context of climate change, and overall human impact on the environment.

Discussion and Conclusions

This study compared the similarities and differences in content between the NAEP Science Framework and the standards of states that have not fully adopted the NGSS. We followed the approach that was used in a previous NAEP framework comparison that allowed for quantification of the overlap in content between NAEP and states' content standards. In the remainder of this section, we discuss our major conclusions.

1. **When examining the content covered by the full set of states' science standards (with any NGSS performance expectations removed), there are many state statements that do not overlap with any NAEP statement.**
    - At grade 4, 31% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.
    - At grade 8, 32% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.
    - At grade 12, 55% of all state content statements reviewed by HumRRO experts and external science experts were rated as not overlapping a NAEP content statement.
    - This is likely due to the multi-purpose design of the state standards (i.e., state standards were developed to guide more than assessment development). For example, some content statements, particularly at the high school level, include very specialized topics intended to guide instruction in advanced level courses that are beyond the content assessed by NAEP. NAEP frameworks, however, are not designed for instructional purposes.

2. **When examining the content covered only by the states' standards the experts reviewed, all NAEP statements overlap in content with at least one state statement, in most cases they overlap in content with multiple state statements, and in some cases NAEP content statements are fully reflected in a combination of multiple state content statements.**
    - For each NAEP content statement HumRRO identified multiple state content statements with overlapping content. Review by external experts verified content overlap with at least one of these pairings for each NAEP content statement.
    - Experts noted that there were instances where a combination of state content statements would fully cover the content in a NAEP content statement.
    - Experts rated most states' statements as at least partially overlapping in content with a NAEP statement.
    - For almost every state included in the current study, there tended to be more content statements in each domain relative to the number of NAEP content statements.
    - Experts perceived the NAEP statements to be written more broadly and they noted key elements of state content that were not addressed by the NAEP statements.

3. **The experts perceived the least amount of content overlap between NAEP and states' standards at the high school level.**
    - Overall at grade 12, 19% of state content statements reviewed by expert panelists were rated as having no content overlap with a NAEP content statement.
    - We do not find this surprising given the breadth and depth of content covered in states' high school standards. High school science standards are often organized at the domain level and contain content ranging from basic to very advanced courses. However, this is the opposite pattern observed when the NAEP Science Framework was compared to the NGSS. In that study, NGSS and NAEP were found to be more similar in content at the high school level, and the level of similarity increased as grade levels increased. This difference in finding between the current and previous studies may in part be a function of the large number of state content statements reviewed in the current study, particularly at the high school level. Another factor contributing to this finding may be that NAEP is more similar to NGSS than non-NGSS content in high school. In this study, experts only looked at the non-NGSS content which many states use to supplement the NGSS.
4. **As with the NAEP-to-NGSS comparison, experts perceived the least amount of overlap in content between NAEP and states' standard for the Physical Science domain, especially at grades 8 and 12**.
    - At grade 8, 9% of state Physical Science content statements reviewed by expert panelists were rated as not overlapping a NAEP content statement.
    - At grade 12, 25% of state Physical Science content statements reviewed by expert panelists were rated as not overlapping a NAEP content statement.
    - The consensus statements indicate several topics addressed by states that are not covered by NAEP. Common across the grade level consensus statements was that NAEP statements tend to not include application, particularly engineering and technology applications.
5. **The science experts perceived that state content statements most frequently reflect NAEP's Identifying Science Practices practice at grades 4 and 8 and Using Science Practices at grade 12. The experts least frequently rated the states' content statements as reflecting Using Scientific Inquiry.**
    - At grades 4 and 8, 54% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's Identifying Science Practices.
    - At grade 12, 51% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's Using Science Practices.
    - Across the grade levels, between 1% and 5% of all state content statements reviewed by expert panelists were rated as reflecting NAEP's Using Technological Design.
    - This finding contrasts with those from the NAEP-to-NGSS comparison, where NGSS performance expectations were most frequently rated as reflecting Using Science Practices, followed by Using Scientific Inquiry. It is possible this difference reflects the design of the current study given we did not include any engineering and technology content that states classified separately from their science content standards.

6. **Science experts noted that states whose standards are based on the NRC K–12 Science Framework have more in common with NAEP that states whose standards are not based on the framework.**
    - Consensus statements developed by both the grade 8 and grade 12 expert panels included assertions that they observed more content overlap between NAEP and the science standards of states who based their standards on the NRC K–12 Science Framework.

Overall, we found substantial overlap between the content outlined in the NAEP Science Framework and the content outlined in the science content standards of states that have not formally and fully adopted the NGSS. Many of the differences in content are likely attributable to the different purposes of the NAEP framework and the states' standards; the former guides assessment whereas the latter guide not only assessment, but curriculum and instruction for a broad array of science courses. Still, science experts made note of several key content topics that are not currently addressed in the NAEP Science Framework, but which they consider important for gauging students' science knowledge.

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Appendix A: Structure of Non- and Partial-NGSS State Science Standards

Table A1. Structure and Description of Non-NGSS State Science Standards

Non-NGSS States	Structure and Description of Science Standards
Florida	Hierarchical structure in grades K-8 with "Big Ideas" (e.g., Forms of Energy) as an overarching structure. Big Ideas have a set of grade level ideas with more specific "benchmarks" or content statements for each Big Idea (https://www.cpalms.org/Public/PreviewIdea/Preview/518). High school standards are organized around Body of Knowledge (e.g., Life Science), standards (e.g., Organization and Development of Living Organisms), sub-standards (e.g., Cells have characteristic structures and functions that make them distinctive), and benchmarks (i.e., performance expectations). A level of content complexity is assigned to each benchmark. Includes Nature of Science (https://www.cpalms.org/Public/PreviewIdea/Preview/585).
North Carolina	Uses Science as Inquiry framework with three domains: Physical Science, Earth Science, and Life Science. Within domains, there are sub-domains, essential standards, and clarifying objectives (i.e., performance expectations). https://www.dpi.nc.gov/teach-nc/curriculum-instruction/standard-course-study/science
Ohio	"Ohio's Learning Standards for Science is significantly different from NGSS, but the research that provided the framework from which each were developed is the same" (http://education.ohio.gov/Topics/Learning-in-Ohio/Science/Ohios-Learning-Standards-and-MC). Ohio standards include grade band themes and strand connections. They use the 5E Learning Cycle: Engage, Explore, Explain, Elaborate, and Evaluate. The first four E's occur in a cycle with the fifth E, Evaluate, woven through every step. State and NGSS standards address similar science content, skills, and ways of thinking. Resources and strategies designed for NGSS are deemed useful for implementing state standards by the Ohio Department of Education. "Teachers are encouraged to use NGSS to support classroom instruction" (http://education.ohio.gov/Topics/Learning-in-Ohio/Science/Ohios-Learning-Standards-and-MC). Ohio includes NGSS Scientific and Engineering Practices (SEP) verbatim.
Pennsylvania	Multiple science standards: Science, Technology, and Engineering; Environment and Ecology; Family and Consumer Sciences; Business, Computer, and Information Technology (https://www.pdesas.org/Page/Viewer/ViewPage/11); reading and writing for "science and technical subjects" (https://www.pdesas.org/Page/Viewer/ViewPage/11); and Computer Science (https://www.pdesas.org/Page/Viewer/ViewPage/11). In September 2019, began reviewing state standards to update them based on the NGSS (https://www.education.pa.gov/Teachers%20-%20Administrators/Curriculum/Science/Pages/Science-Standards.aspx).

Table A1. Structure and Description of Non-NGSS State Science Standards (Continued)

Non-NGSS States	Structure and Description of Science Standards
Texas	Science is interdisciplinary. Performance expectations (i.e., content statements) are organized around grade-level strands (e.g., scientific investigations and reasoning, matter and energy; ritter.tea.state.tx.us/rules/tac/chapter112/ch112a.html#112.14). In high school, scientific processes and science content within each content domain (which are tied to high school courses) are used to organize the performance expectations (ritter.tea.state.tx.us/rules/tac/chapter112/ch112c.html#112.34).
Virginia	Content strands (Force, Motion, and Energy; Living Systems and Processes; Earth Resources) or topics progress in complexity. Six components for achieving science literacy: Goals, Investigate and Understand, Nature of Science, Science and Engineering Practices (SEP), K-12 Safety, Instructional Technology. Components support "integrated instructional approach that incorporates science, technology, engineering, and mathematics (STEM)" (p. iv).[7] Science skills and processes contribute to overall student skills: communication, collaboration, critical thinking, creative thinking, and civic responsibility.
West Virginia	Although the National Science Teachers Association (NSTA) classifies West Virginia's science standards as based on the NGSS (https://ngss.nsta.org/about.aspx), their state standards do not include major features of the NGSS. They do not include Crosscutting Concepts, SEP, and three-dimensional structure. In addition to the four NGSS Disciplinary Core Ideas (DCI), West Virginia's standards include additional concepts (e.g., chemistry, physics, forensic science). https://apps.sos.wv.gov/adlaw/csr/readfile.aspx?DocId=26574&Format=PDF https://wvde.us/tree/early-learning-p-5/ https://wvde.us/tree/middlesecondary-learning/science/

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Table A2. Structure and Description of Partial NGSS State Science Standards

Partial NGSS States	Structure and Description of Science Standards
Alabama	High-level structure identical to NGSS. Added to NGSS are interdisciplinary connections, laboratory safety, nature of science, and scientific writing. They use the 5E + IA Instructional Model: Engage, Explore, Explain, Elaborate, Evaluate, Acceleration, and Intervention. The first four E's occur in a cycle with the fifth E, Evaluate, woven through every step. Acceleration and Intervention occur within the five Es. https://www.alsde.edu/sec/sct/COS/2015%20FINAL%20Science%20COS%2010-1-15.pdf
Alaska	High-level structure identical to NGSS. Added many examples of scientific principles and skills in an Alaskan context. A small number of content statements were tweaked for clarity or age-appropriateness, or were combined, moved to a different grade, or deleted. https://education.alaska.gov/akstandards/science/science-standards-for-alaska.pdf
Arizona	High-level structure identical to NGSS. Removed Engineering, Technology, and the Application of Science from the DCIs. https://www.azed.gov/standards-practices/k-12standards/standards-science/
Colorado	High-level structure identical to NGSS. Removed Engineering, Technology, and the Application of Science from the DCIs (https://www.cde.state.co.us/coscience/2020cas-sc-p12). Will not fully implement these new standards until 2021-2022 school year (https://www.cde.state.co.us/coscience/statestandards).
Department of Defense Education Activity (DoDEA)	With 2019-2020 school year, used NGSS in grades 6-12. Grades K-5 standards borrow heavily from the NGSS. https://www.dodea.edu/Curriculum/Science/standards.cfm
Georgia	The Science Georgia Standards of Excellence (GSE) are based on the NGSS, but the only commonality is the three content domains: Life Science, Physical Science, and Earth and Space Sciences. There is limited mention of the SEP or Crosscutting Concepts (CCC). For high school, there are many subject-specific standards (e.g., Botany, Geology, Meteorology, Zoology). https://www.georgiastandards.org/Georgia-Standards/Pages/Science.aspx
Idaho	High-level structure identical to NGSS. Removed Engineering, Technology, and the Application of Science from the DCI. https://sde.idaho.gov/academic/shared/science/ICS-Science-Legislative.pdf
Indiana	Science Standards include SEP (referred to as Science and Engineering Process Standards [SEPS]) and DCI with numerous word changes (e.g., NGSS SEP "asking questions…" is "posing questions…" in Indiana. Resource Guide includes CCCs. Engineering, Technology, and the Application of Science called "Engineering." https://www.doe.in.gov/standards/science-computer-science
Louisiana	Added Environmental Science to SEP, DCI, and CCC. DCIs. https://www.louisianabelieves.com/resources/library/academic-standards

Table A2. Structure and Description of Partial NGSS State Science Standards (Continued)

Partial NGSS States	Structure and Description of Science Standards
Massachusetts	Uses SEP and DCI, although Engineering, Technology, and the Application of Science is called "Technology/Engineering." Adds Application, to apply understanding and skills, as an interrelated component with SEP and DCI. Additional changes to NGSS include technology/engineering as a discipline equivalent to traditional sciences. Does not formally include CCC. Instead encourages inclusion of and nature of science in curriculum. Balances broad concepts with specificity. https://www.doe.mass.edu/frameworks/scitech/2016-04.pdf
Minnesota	High-level structure identical to NGSS. Draft standards available for use by teachers, and currently developing assessments based on these standards. https://education.mn.gov/MDE/dse/stds/sci/
Mississippi	High-level structure identical to NGSS. Removed Engineering, Technology, and the Application of Science from the DCIs. Added DCI domains (e.g., Science and Society, History of Science). https://www.mdek12.org/sites/default/files/documents/Secondary%20Ed/2018-ms_ccrs---sci_k-12_final_20171006.pdf
Missouri	Uses SEP and CCC from NGSS. DCI are adapted. Added some content statements and deleted some NGSS content statements. In grade 4, one of the added statements is: "Plan and conduct scientific investigations or simulations to provide evidence how natural processes (e.g., weathering and erosion) shape Earth's surfaces." In grade 4, they did not include the NGSS content statement: "Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen." https://dese.mo.gov/sites/default/files/curr-mls-standards-sci-k-5-sboe-2016.pdf https://dese.mo.gov/sites/default/files/curr-mls-standards-sci-6-12-sboe-2016.pdf
Montana	Uses the DCI, SEP, and CCC. Removed Engineering, Technology, and the Application of Science from the DCIs. http://opi.mt.gov/LinkClick.aspx?fileticket=qHA5q8j-oGw%3d&portalid=182
Nebraska	Follows NGSS closely with the addition of Phenomena to tie together the NGSS' DCI, SEP, and CCC and to shift from learning about a topic to figuring out the "why" of an event or problem. Phenomena "are observable events we use our science knowledge to explain or predict." They apply multiple Performance Expectations and are too complex to solve after one lesson. They are not "Googleable."[8] Interdisciplinary connections include Nebraska connections, civic science connections, computer science connections, and engineering, technology, and applications of science connections. https://cdn.education.ne.gov/wp-content/uploads/2017/10/Nebraska_Science_Standards_Final_10_23.pdf

[8] Nebraska Association of Teachers of Science (NATS). (2017, March 27). Phenomena webinar. https://docs.google.com/presentation/d/1bXC0ZO0WNoDHKGTR9HbtxeffcgDYHd6F9zg_P3KykGA/edit#slide=id.g201fec5611_0_117

Table A2. Structure and Description of Partial NGSS State Science Standards (Continued)

Partial NGSS States	Structure and Description of Science Standards
New York	Uses the NGSS with additions to the DCI. For example, in middle school Physical Science, include "make observations to provide evidence that energy can be transferred by electric currents." In high school Life Sciences, include "use models to illustrate how human reproduction and development maintains continuity of life." http://www.nysed.gov/common/nysed/files/programs/curriculum-instruction/p-12-science-learning-standards.pdf
North Dakota	High-level structure identical to NGSS. Engineering, Technology, and the Application of Science called "Engineering and Technology." https://www.nd.gov/dpi/sites/www/files/documents/Academic%20Support/FINAL%20ND%20Science%20Content%20Standards_rev2.12.10.19.pdf
Oklahoma	High-level structure identical to NGSS. https://drive.google.com/file/d/1776lQL91nBBWkq2jEY25zBhzZhpKUP4V/view
South Carolina	Uses SEP and three of the domains (Life Science, Physical Science, and Earth Science), but does not use a three-dimensional structure. Content statements differ and some core topics are emphasized at different grades (e.g., NGSS include weather and climate at grade 3 whereas South Carolina standards include weather at grade 2 and weather and climate at grade 4). https://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
South Dakota	High-level structure identical to NGSS with some differences in organization. Some verbs in the content statements have been changed (e.g., from "conduct" to "plan and carry out"). Climate change has been de-emphasized. https://doe.sd.gov/contentstandards/documents/sdSciStnd.pdf
Tennessee	High-level structure identical to NGSS. Grade-level content statements created by state. Includes science literacy. https://www.tn.gov/content/dam/tn/stateboardofeducation/documents/massivemeetingsfolder/meetingfiles4/10-20-17_III_J_Non-Substantive_Changes_to_Math_ELA__Science_Standards_Attachment_3_-_Science.pdf
Utah	High-level structure identical to NGSS. Engineering, Technology, and the Application of Science called "Engineering Design." https://schools.utah.gov/file/e5d886e2-19c3-45a5-8364-5bcb48a63097
Wisconsin	High-level structure identical to NGSS. Engineering, Technology, and the Application of Science called "Engineering, Technology, and Society." Formatted differently than NGSS; state standards show grade-level progressions. Added focus on "disciplinary literacy." https://dpi.wi.gov/sites/default/files/imce/standards/New%20pdfs/ScienceStandards2017.pdf
Wyoming	High-level structure identical to NGSS. Includes cross-curricular connections and International Society for Technology in Education (ISTE) connections. State context included with some performance expectations. https://edu.wyoming.gov/downloads/standards/2018/Science-Extended-Standards-2018.pdf

Appendix B: High School Science Standard Topics

Table B1. Non-NGSS States' High School Science Standard Topics Reviewed and Not Reviewed

Non-NGSS States	High School Standard Topics Included in Review	High School Standard Topics Not Included in Review
Florida	Life Science Physical Science Earth and Space Science	Nature of Science Computer Science
North Carolina	Biology Physical Science Earth and Environmental	Chemistry Physics
Ohio	Biology Physical Science Physical Geology	Chemistry Physics Environmental Science Human Anatomy and Physiology
Pennsylvania	Biological Sciences Physical Sciences: Chemistry and Physics Earth and Space Sciences	Environment and Ecology Technology and Engineering Education
Texas	Biology Integrated Physics and Chemistry Earth and Space Science	Chemistry Physics Environmental Systems Aquatic Science Astronomy
Virginia	Biology Chemistry Physics Earth Science	None
West Virginia	Biology (grade 10) Physical Science (3rd course) Earth and Space Science (grade 9)	Chemistry (3rd STEM course) Physics (4th STEM course) Environmental Science Human Anatomy and Physiology Forensic Science

Table B2. Partial NGSS States' High School Science Standard Topics Reviewed and Not Reviewed

Partial NGSS States	High School Standard Topics Included in Review	High School Standard Topics Not Included in Review
Alabama	Biology Physical Science Earth and Space Science	Chemistry Physics Environmental Science Human Anatomy and Physiology
Alaska	Life Sciences Physical Sciences Earth and Space Sciences	None
Arizona	Life Sciences Physical Sciences Earth and Space Sciences	None
Colorado	Life Science Physical Science Earth and Space Science	None
Georgia	Biology Physical Science Earth Systems	Chemistry Physics Environmental Science Human Anatomy and Physiology Astronomy Forensic Science Botany Ecology Geology Meteorology Microbiology Oceanography Zoology
Idaho	Life Science Physical Sciences (Chemistry) Physical Sciences (Physics) Earth and Space Sciences	None
Indiana	Biology Integrated Chemistry and Physics Earth and Space Science	Chemistry Physics I Physics II Environmental Science Anatomy and Physiology

Table B2. Partial NGSS States' High School Science Standard Topics Reviewed and Not Reviewed (Continued)

Partial NGSS States	High School Standard Topics Included in Review	High School Standard Topics Not Included in Review
Louisiana	Life Science Physical Science Earth Science	Chemistry Physics Environmental Science
Massachusetts	Biology Chemistry Introductory Physics Earth and Space Science	Technology/Engineering
Minnesota	Life Science Chemistry Physics Earth and Space Science	None
Mississippi	Biology Physical Science Earth and Space Science	Foundations of Science Literacy Foundations of Biology Chemistry Physics Environmental Science Human Anatomy and Physiology Marine and Aquatic Science I Marine and Aquatic Science II Botany Zoology Genetics
Missouri	Life Sciences Physical Sciences Earth and Space Sciences	Engineering, Technology, and Application of Science
Montana	Life Science Physical Science Earth and Space Science	None
Nebraska	Life Science Physical Science Earth and Space Science	Chemistry Physics Anatomy and Physiology
New York	Life Sciences Physical Sciences Earth and Space Sciences	Engineering, Technology, and Science Applications

Table B2. Partial NGSS States' High School Science Standard Topics Reviewed and Not Reviewed (Continued)

Partial NGSS States	High School Standard Topics Included in Review	High School Standard Topics Not Included in Review
North Dakota	Life Science Physical Science Earth and Space Science	Engineering and Technology
Oklahoma	Biology Physical Science Earth and Space Science	Chemistry Physics Environmental Science
South Carolina	Biology Chemistry Physics Earth Science	None
South Dakota	Life Science Physical Science Earth/Space Science	None
Tennessee	Biology I Physical Science Earth and Space Science	Scientific Research Biology II Physical World Concepts Chemistry I Chemistry II Physics Human Anatomy and Physiology Ecology
Utah	Biology Chemistry Physics Earth and Space Science	None
Wisconsin	Life Science Physical Science Earth and Space Science	Engineering, Technology, and Science Applications
Wyoming	Life Science Physical Science Earth and Space Science	Engineering, Technology, and Applications of Science

Appendix C: High School Science Assessments and Graduation Requirements

Table C1. Summary of Non-NGSS States' High School Science Assessments and Graduation Requirements

Non-NGSS States	Number of Science Credits Required for Graduation	High School Science Assessment(s)	Stakes of High School Science Assessment(s)	Types of Science Graduation Credits Required
Florida	3 credits	Biology 1	30% of grade	Two of the three required credits must have a laboratory component. A student must earn one credit in Biology I and two credits in equally rigorous courses. The statewide, standardized Biology I end of course (EOC) assessment constitutes 30 percent of the student's final course grade.
North Carolina	3 credits	Biology	>= 20% of grade	1. a physical science course; 2. Biology; 3. an earth/environmental science course
Ohio	3 credits	Biology	Must earn 18 points (1-5 scale) across 7 exams including Biology	Must include one unit of physical sciences, one unit of life sciences, and one unit of advanced study in one or more of the following sciences: chemistry, physics or other physical science; advanced biology or other life science; astronomy, physical geology, or other earth or space science.
Pennsylvania	3 credits	Biology	none	
Texas	3 credits	Biology	Passing score	Biology, Integrated Physics and Chemistry or an advanced science course, and an advanced science course.
Virginia	3 credits	Earth Science, Biology, or Chemistry	Pass 1 of the 3 EOC exams	At least two different science disciplines: earth sciences, biology, chemistry, or physics
West Virginia	3 credits	Grade 10 Biology	none	Physical Science (Grade 9), Biology or Conceptual Biology or AP Biology (Grade 10), and one additional lab science course or AP science course.

Table C2. Summary of Partial NGSS States' High School Science Assessments and Graduation Requirements

Partial NGSS States	Number of Science Credits Required for Graduation	High School Science Assessment(s)	Stakes of High School Science Assessment(s)	Types of Science Graduation Credits Required
Alabama	4 credits	Biology	yes	Biology 1 and a physical science (Chemistry, Physics, Physical Science) required
Arkansas	2 credits	Grade 10 science	none	Grade 9 and 10 science
Arizona	3 credits	Arizona's Instrument to Measure Standards (AIMS) Science (grade 10)	none	AIMS Science was in effect prior to August 21, 2020. AzSCI is in census field testing and aligns to new standards.
Colorado	no specific requirements	Grade 11 Science	none	Grade 11 Science Summative Assessment Framework: Physical Science, Life Science, Earth Systems Science, Scientific Investigations, and the Nature of Science,
Georgia	4 credits	Biology and Physical Science	20% of grade	One unit of Biology; one unit of either Physical Science or Physics; one unit of either Chemistry, Earth Systems, or Environmental Science or an Advanced Placement/International Baccalaureate (AP/IB) course; and one additional science unit.
Idaho	6 credits (4 lab based)	Grade 11 Science	none	Science courses may include Biology, Physical Science, Chemistry, Earth, Space, and Environment or approved applied science. Grade 11 science comprehensive assessment allows students to demonstrate mastery of the science and engineering practices and crosscutting concepts woven into the life, physical (physics and chemistry), and earth and space sciences.
Indiana	4 credits	none	none	2 credits: Biology; 2 credits: Any science course. At least one credit must be from a Physical Science or Earth and Space Science course
Louisiana	2 credits	Biology	none	Biology and 2nd course which may include one of the following: Chemistry I, Physical Science, Earth Science, and others.

Table C2. Summary of Partial NGSS States' High School Science Assessments and Graduation Requirements (Continued)

Partial NGSS States	Number of Science Credits Required for Graduation	High School Science Assessment(s)	Stakes of High School Science Assessment(s)	Types of Science Graduation Credits Required
Massachusetts	3 credits of lab-based science	1 Science and Technology/ Engineering (STE) assessment	yes	STE assessments: Biology, Chemistry, Introductory Physics, or Technology/Engineering
Minnesota	3 credits	Biology	none	Courses must include: Biology and one course in Chemistry, Physics, or CTE.
Mississippi	4 credits	Biology	yes	Biology I required
Missouri	3 credits	Biology	none	
Montana	2 credits	ACT with Writing	none	
Nebraska	3 credits	ACT	none	
New York	3 credits	Regents exam	yes	Life Science and Physical Science courses required
North Dakota	3 credits	Grade 10 science	none	Biology/Chemistry/Physics or Biology/Physical Science/science elective
Oklahoma	3 credits	College and Career Readiness Assessment (CCRA) Science	none	Biology I, and 2 courses in the areas of life, physical, or earth science or technology
South Carolina	3 credits	Biology I	none	
South Dakota	3 credits	Grade 11 Science	none	Biology and 2 science electives
Tennessee	3 credits	Biology	% of grade	Biology, Chemistry or Physics, and a third lab course
Utah	3 credits	Utah ASPIRE Plus Science	none	Two courses from the following five areas: earth science, biological science, chemistry, physics, or computer science.
Wisconsin	3 credits	ACT ASPIRE and ACT with Writing	none	
Wyoming	3 credits	Wyoming Test of Proficiency and Progress (WY-TOPP) Grade 10 Science	% of grade	

Appendix D: Number of Initially Compiled State Content Statements

Table D1. Number and Percent of Science Content Statements Compiled Across States, by Grade and Domain

Grade	Domain	N	Percent
4	Earth and Space Science	354	24.8%
4	Life Science	332	23.3%
4	Physical Science	391	27.4%
4	Other	348	24.4%
Total Grade 4		1,425	100%
8	Earth and Space Science	796	25.8%
8	Life Science	827	26.8%
8	Physical Science	970	31.4%
8	Other	494	16.0%
Total Grade 8		3,087	100%
12	Earth and Space Science	764	24.7%
12	Life Science	969	31.3%
12	Physical Science	1221	39.5%
12	Other	140	4.5%
Total Grade 12		3,094	100%

Note: Counts include NGSS content and content that was not categorized in one of the three major science domains, all of which were removed prior to the process of reviewing content statements for overlap with NAEP content.

Appendix E: Content Statements by Domain and State

Grade 4

Table E1. Number and Percent of Grade 4 Content Statements by State Type, State, and NAEP Science Practice

State Type	State	ESS N	ESS %	PS N	PS %	LS N	LS %
Non-NGSS	FL	20	6.6%	21	7.5%	14	5.9%
Non-NGSS	NC	14	4.6%	22	7.9%	16	6.7%
Non-NGSS	OH	7	2.3%	6	2.2%	5	2.1%
Non-NGSS	PA	26	8.6%	30	10.8%	24	10.0%
Non-NGSS	TX	19	6.3%	17	6.1%	15	6.3%
Non-NGSS	VA	32	10.6%	9	3.2%	16	6.7%
Non-NGSS	WV	1	0.3%	2	0.7%	1	0.4%
Partial NGSS	AK	2	0.7%	1	0.4%	0	0.0%
Partial NGSS	AL	10	3.3%	15	5.4%	14	5.9%
Partial NGSS	AZ	7	2.3%	7	2.5%	5	2.1%
Partial NGSS	CO	2	0.7%	0	0.0%	0	0.0%
Partial NGSS	DoDEA	2	0.7%	0	0.0%	1	0.4%
Partial NGSS	GA	25	8.3%	17	6.1%	11	4.6%
Partial NGSS	ID	3	1.0%	1	0.4%	1	0.4%
Partial NGSS	IN	9	3.0%	7	2.5%	5	2.1%
Partial NGSS	LA	6	2.0%	1	0.4%	4	1.7%
Partial NGSS	MA	8	2.6%	8	2.9%	9	3.8%
Partial NGSS	MN	11	3.6%	3	1.1%	7	2.9%
Partial NGSS	MO	3	1.0%	9	3.2%	7	2.9%
Partial NGSS	MS	26	8.6%	22	7.9%	21	8.8%
Partial NGSS	MT	8	2.6%	4	1.4%	2	0.8%
Partial NGSS	ND	5	1.7%	5	1.8%	3	1.3%
Partial NGSS	NE	1	0.3%	2	0.7%	3	1.3%
Partial NGSS	NY	3	1.0%	1	0.4%	0	0.0%
Partial NGSS	OK	2	0.7%	2	0.7%	2	0.8%
Partial NGSS	SC	20	6.6%	18	6.5%	13	5.4%
Partial NGSS	SD	2	0.7%	8	2.9%	4	1.7%
Partial NGSS	TN	15	5.0%	14	5.0%	11	4.6%
Partial NGSS	UT	5	1.7%	14	5.0%	12	5.0%
Partial NGSS	WI	7	2.3%	13	4.7%	12	5.0%
Partial NGSS	WY	2	0.7%	0	0.0%	1	0.4%

Note: ESS= Earth and Space Sciences; LS= Life Science; PS= Physical Science

Grade 8

Table E2. Number and Percent of Grade 8 Content Statements by State Type, State, and NAEP Science Practice

State Type	State	ESS N	ESS %	PS N	PS %	LS N	LS %
Non-NGSS	FL	36	6.3%	43	5.6%	27	3.9%
Non-NGSS	NC	24	4.2%	45	5.8%	44	6.3%
Non-NGSS	OH	18	3.2%	14	1.8%	11	1.6%
Non-NGSS	PA	47	8.3%	51	6.6%	36	5.2%
Non-NGSS	TX	42	7.4%	50	6.5%	48	6.9%
Non-NGSS	VA	31	5.5%	93	12.1%	65	9.3%
Non-NGSS	WV	5	0.9%	4	0.5%	5	0.7%
Partial NGSS	AK	11	1.9%	10	1.3%	9	1.3%
Partial NGSS	AL	28	4.9%	30	3.9%	24	3.4%
Partial NGSS	AZ	16	2.8%	22	2.9%	17	2.4%
Partial NGSS	CO	3	0.5%	4	0.5%	3	0.4%
Partial NGSS	DoDEA	0	0.0%	1	0.1%	0	0.0%
Partial NGSS	GA	36	6.3%	42	5.5%	35	5.0%
Partial NGSS	ID	5	0.9%	2	0.3%	11	1.6%
Partial NGSS	IN	13	2.3%	26	3.4%	26	3.7%
Partial NGSS	LA	8	1.4%	5	0.6%	10	1.4%
Partial NGSS	MA	21	3.7%	31	4.0%	24	3.5%
Partial NGSS	MN	15	2.6%	22	2.9%	20	2.9%
Partial NGSS	MO	10	1.8%	14	1.8%	15	2.2%
Partial NGSS	MS	58	10.2%	69	9.0%	56	8.1%
Partial NGSS	MT	8	1.4%	16	2.1%	9	1.3%
Partial NGSS	ND	22	3.9%	37	4.8%	40	5.8%
Partial NGSS	NE	7	1.2%	7	0.9%	9	1.3%
Partial NGSS	NY	4	0.7%	12	1.6%	10	1.4%
Partial NGSS	OK	8	1.4%	9	1.2%	6	0.9%
Partial NGSS	SC	36	6.3%	42	5.5%	46	6.6%
Partial NGSS	SD	3	0.5%	8	1.0%	6	0.9%
Partial NGSS	TN	27	4.8%	29	3.8%	37	5.3%
Partial NGSS	UT	9	1.6%	9	1.2%	14	2.0%
Partial NGSS	WI	11	1.9%	20	2.6%	26	3.7%
Partial NGSS	WY	6	1.1%	3	0.4%	7	1.0%

Note: ESS= Earth and Space Sciences; LS= Life Science; PS= Physical Science

Grade 12

Table E3. Number and Percent of Grade 12 Content Statements by State Type, State, and NAEP Science Practice

State Type	State	ESS N	ESS %	PS N	PS %	LS N	LS %
Non-NGSS	FL	27	4.3%	53	4.9%	117	14.7%
Non-NGSS	NC	40	6.4%	44	4.1%	44	5.5%
Non-NGSS	OH	8	1.3%	194	18.0%	49	6.2%
Non-NGSS	PA	41	6.6%	91	8.4%	95	12.0%
Non-NGSS	TX	68	10.9%	35	3.2%	53	6.7%
Non-NGSS	VA	57	9.1%	75	7.0%	60	7.6%
Non-NGSS	WV	10	1.6%	10	0.9%	4	0.5%
Partial NGSS	AK	7	1.1%	12	1.1%	6	0.8%
Partial NGSS	AL	19	3.0%	20	1.9%	27	3.4%
Partial NGSS	AZ	7	1.1%	15	1.4%	12	1.5%
Partial NGSS	CO	7	1.1%	10	0.9%	6	0.8%
Partial NGSS	DoDEA	0	0.0%	0	0.0%	0	0.0%
Partial NGSS	GA	32	5.1%	49	4.5%	31	3.9%
Partial NGSS	ID	6	1.0%	12	1.1%	6	0.8%
Partial NGSS	IN	37	5.9%	52	4.8%	18	2.3%
Partial NGSS	LA	7	1.1%	13	1.2%	13	1.6%
Partial NGSS	MA	14	2.2%	29	2.7%	21	2.6%
Partial NGSS	MN	18	2.9%	24	2.2%	15	1.9%
Partial NGSS	MO	12	1.9%	17	1.6%	18	2.3%
Partial NGSS	MS	7	1.1%	11	1.0%	11	1.4%
Partial NGSS	MT	7	1.1%	16	1.5%	11	1.4%
Partial NGSS	ND	26	4.2%	35	3.2%	30	3.8%
Partial NGSS	NE	20	3.2%	16	1.5%	11	1.4%
Partial NGSS	NY	7	1.1%	16	1.5%	10	1.3%
Partial NGSS	OK	15	2.4%	10	0.9%	8	1.0%
Partial NGSS	SC	49	7.9%	99	9.2%	40	5.0%
Partial NGSS	SD	4	0.6%	12	1.1%	8	1.0%
Partial NGSS	TN	31	5.0%	36	3.3%	23	2.9%
Partial NGSS	UT	21	3.4%	43	4.0%	23	2.9%
Partial NGSS	WI	11	1.8%	15	1.4%	15	1.9%
Partial NGSS	WY	8	1.3%	14	1.3%	9	1.1%

Note: ESS= Earth and Space Sciences; LS= Life Science; PS= Physical Science

Appendix F: Sample Workshop Materials

Rating Form Excerpt

Table F1. Sample Science Standards Review Rating Form

NAEP Code	NAEP Content Statement	State Content Statement	State	Similar Content Statement	Content Alignment 2 = Full overlap 1 = Partial overlap 0 = No overlap	NAEP Practices Alignment 1 = Primary 2 = Secondary				Notes
						ISP	ISP	USP	USI	
L4.4	When the environment changes, some plants and animals survive and reproduce; others die or move to new locations.	Adaptations may be behavioral or physical	VA							
		Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful	OH							
		Fossils can be compared to one another and to present-day organisms according to their similarities and differences	OH							
		Populations may adapt over time	VA							
		Some living organisms resemble organisms that once lived on earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	WI	Fossils provide evidence about the types of organisms that lived long ago as well as the nature of their environments (VA)						

Content Overlap Rating Guidance

The table below describes the three ratings for comparing NAEP content statements to state content statements.

Table F2. Summary of Content Overlap Rating Categories

Rating	Description
Full overlap	All essential content in the state content statement is also contained in the NAEP content statement.
Partial overlap	Some essential content in the state content statement is not in the NAEP content statement.
No overlap	The essential content measured by the two content statements is different.

Another way to visualize this is a bucket. When the state content statement is in the NAEP content statement bucket, even if it does not fill the bucket, there is full overlap. If there is some part of the state content statement that falls outside the NAEP bucket, then there is partial overlap.

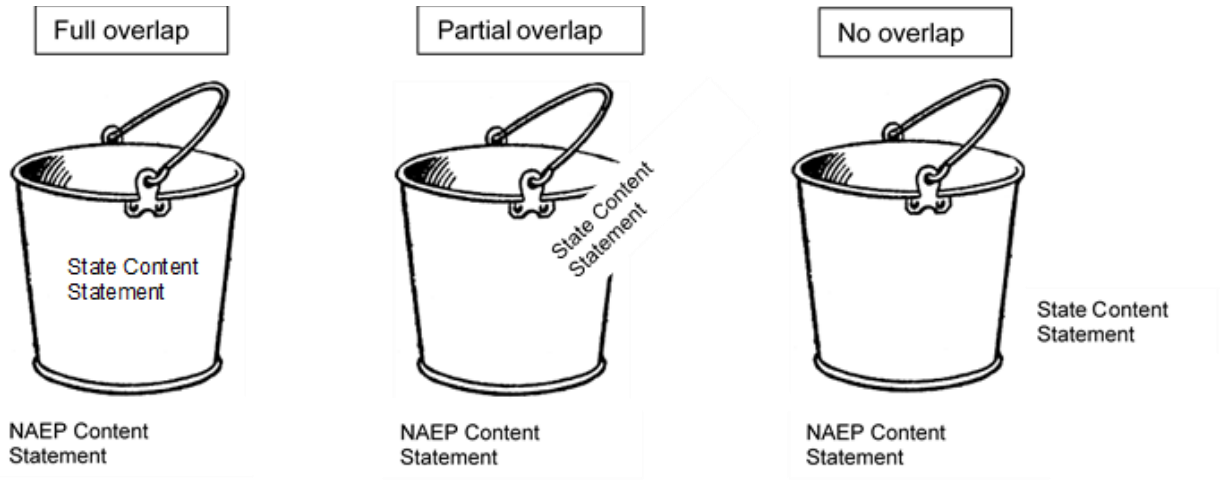

Figure F1. Bucket analogy for full, partial, and no content overlap ratings.

The overarching goal is to inform the NAEP Framework Committees on what states are teaching that NAEP does not cover, so they can discuss whether it's something NAEP should test (and include in the new framework). In the study report, the percentages of full and partial ratings will provide an indication of the extent to which states teach content that is not included in the NAEP framework.

Overview of Science Practices in NAEP Science Assessment

The National Assessment of Educational Progress (NAEP) Science assessment measures students' knowledge in the Physical, Life, and Earth and Space Sciences. Additionally, it measures students' knowledge in the following four science practices: (a) identifying science principles, (b) using science principles, (c) using scientific inquiry, and (d) using technological design. These four practices describe how students use their science knowledge by measuring what they can do with the science content.
The NAEP science practices are described as follows:

1. **Identifying Science Principles (ISP)** focuses on students' ability to recognize, recall, define, relate, and represent basic science principles in each of the three content areas. Identifying Science Principles is integral to all the other science practices.

2. **Using Science Principles (USP)** focuses on the importance of science knowledge in making accurate predictions about and explaining observations of the natural world.

3. **Using Scientific Inquiry (USI)** focuses on designing, critiquing, and evaluating scientific investigations; identifying patterns in data; and using empirical evidence to validate or criticize conclusions.

4. **Using Technological Design (UTD)** focuses on the systematic process of applying science knowledge and skills to propose or critique solutions to real world problems, identify trade-offs, and anticipate effects of technological design decisions.

The science practices are not content-free skills; they require knowledge of the Physical, Life, and Earth and Space Sciences as well as knowledge about scientific inquiry and the nature of science (e.g., drawing conclusions from investigations).

The table below presents the general types of performance expectations associated with the NAEP science practices. Performance expectations are derived from the intersection of content statements and science practices. Performance expectations may overlap because the content and practice categories themselves are not distinct.

Table F3. NAEP Science Practices and General Types of Performance Expectations

Science Practice	Performance Expectations
ISP	• Describe, measure, or classify observations (e.g., describe the position and motion of objects; measure temperature; classify relationships between organisms as being predator/prey, parasite/host, producer/consumer). • State or recognize correct science principles (e.g., mass is conserved when substances undergo changes of state; all organisms are composed of cells; the atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor). • Demonstrate relationships among closely related science principles (e.g., connect statements of Newton's three laws of motion, relate energy transfer with the water cycle). • Demonstrate relationships among different representations of principles (e.g., verbal, symbolic, diagrammatic) and data patterns (e.g., tables, equations, graphs).
USP	• Explain observations of phenomena (using science principles from the content statements). • Predict observations of phenomena (using science principles from the content statements, including quantitative predictions based on science principles that specify quantitative relationships among variables). • Suggest examples of observations that illustrate a science principle (e.g., identify examples where the net force on an object is zero; provide examples of observations explained by the movement of tectonic plates; given partial DNA sequences of organisms, identify likely sequences of close relatives). • Propose, analyze, and/or evaluate alternative explanations or predictions.
USI	• Design or critique aspects of scientific investigations (e.g., involvement of control groups, adequacy of sample). • Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision). • Identify patterns in data and/or relate patterns in data to theoretical models. • Use empirical evidence to validate or criticize conclusions about explanations and predictions (e.g., check to see that the premises of the argument are explicit, notice when the conclusions do not follow logically from the evidence presented).
UTD	• Propose or critique solutions to problems, given criteria and scientific constraints. • Identify scientific tradeoffs in design decisions and choose among alternative solutions. • Apply science principles or data to anticipate effects of technological design decisions.

Source: https://www.nagb.gov/content/nagb/assets/documents/publications/frameworks/science/2015-science-framework.pdf

NAEP-State Science Standards Review
Expert Panelist Instructions

Panelist Folder Contents

Table F4. Summary of Panelist Folder Contents

Folder name	Subfolder name	File name	File type
Panelist First, Initial, Last Name - Grade		*Grade Domain* Rating Form (3 files)	Excel
	State Overall Rating Forms	*Grade - State (31 files*)*	Excel
	Support Materials	Panelist Instructions	Word
		NAEP Science Practices Overview	Word
		Science Framework for the 2015 National Assessment of Educational Progress	PDF
	State Content Standards		
	State (31 subfolders)	Varies	Varies

Note: Elements of file/folder names in *italics* will vary depending on grade, science domain, and/or state.
*There are 30 state overall rating forms and state standards subfolders for high school; DoDEA uses NGSS at high school level.

Content Overlap Ratings

1. Access *Grade Domain* Rating Form.
    a. Click link in email to access your folder on Google Drive.
    b. Right click on the file name and select "Open With" and "Google Sheets" to open the file.
        i. There is a separate rating form for each of the three science domains (Physical Science, Life Science, Earth and Space Science).
2. Familiarize yourself with the worksheets and data fields, then enter your ratings.
    a. Each worksheet tab corresponds with a single NAEP content statement.
        i. You will make similar ratings in each worksheet.
    b. Column A contains the code of the NAEP content statement.
    c. Column B contains the text of the NAEP content statement.
    d. Column C contains the text of the state content statement.
    e. Column D contains the state(s) from which the content statement comes.

f. Column E contains other content statements that have been identified as very similar to the content statement in column D.
    i. State abbreviation is in parentheses after each content statement.
    ii. The ratings you make for the state in column D will also be applied to the other similar content statement(s) listed in column E.
    iii. If you think any of the other similar content statements should be rated differently, enter this different rating for the appropriate similar content statement(s) in the Notes column (column K).

g. In column F, indicate whether the content in content statement in column D fully overlaps (2), partially overlaps (1), or does not overlap (0) the content of the NAEP content statement in column B.

h. In columns G through J, indicate which of the NAEP science practices is primarily reflected in the state content statement presented in column D.
    i. Refer to the NAEP Science Practices Overview document for information on the NAEP science practices.
    ii. Enter a 1 in the cell that corresponds with the selected NAEP science practice.
    iii. If you feel there is another NAEP science practice that the state content statement in column D also reflects, enter a 2 in the cell that corresponds with that NAEP science practice. Note you are not required to identify a secondary NAEP science practice for each state content statement.
    iv. If you feel the state content statement does not reflect any NAEP content statement, leave cells G through J blank and enter a related comment in column K.

i. In column K, enter any additional notes regarding the NAEP science practices and state content statements.

State Overall Ratings

1. Access *Grade - State* file.
    a. Click link in email to access your folder on Google Drive.
    b. Click on the State Overall Rating Forms subfolder.
    c. Right click on the file name and select "Open With" and "Google Sheets" to open the file.
        i. There is a separate file for each of the 31 included states (30 for high school).
2. Familiarize yourself with the worksheets and data fields, then enter your ratings.
    a. Each worksheet tab corresponds to one of the three science domains (Physical Science, Life Science, Earth and Space Science).
        i. You will make similar ratings in each worksheet.
    b. Column A lists all the NAEP content statements for the domain.

c. Column B lists all the state content statement for the domain.
    i. This includes any NGSS content or content that was not linked to NAEP for the content overlap ratings task.

d. In column C, provide an overall rating of the level of overlap between all the NAEP content statements and all the content statements for the state:
    i. 1= Exactly or almost the same
    ii. 2= Quite similar, but with some differences
    iii. 3= Quite dissimilar, but with some overlap
    iv. 4= Substantially or wholly different

e. In columns D through G, enter an X into the column if the NAEP science practice is reflected in the state content statements.

f. In column H, provide comments about any key ways in which the NAEP content statements and content statements for the state differ.

Appendix G: NAEP Statements with Content Overlap Ratings

Grade 4 Earth and Space Sciences

Table G1. Content Overlap Ratings for Grade 4 Earth and Space Sciences NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	2	19	5
E4.2	The observable shape of the Moon changes from day to day in a cycle that lasts about a month.	0	2	4
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.	10	18	23
E4.4	Earth materials that occur in nature include rocks minerals soils water and the gases of the atmosphere.	1	5	2
E4.5	Natural materials have different properties that sustain plant and animal life.	0	2	4
E4.6	Some Earth materials have properties either in their present form or after design and modification that make them useful in solving human problems and enhancing the quality of life as in the case of materials used for building or fuels used for heating and transportation.	2	1	24
E4.7	The Sun warms the land air and water and helps plants grow.	1	3	5
E4.8	Weather changes from day to day and during the seasons.	1	2	11
E4.9	Scientists use tools for observing recording and predicting weather changes from day to day and during the seasons.	0	3	10
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	13	11
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.	0	17	9

Grade 4 Life Science

Table G2. Content Overlap Ratings for Grade 4 Life Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
L4.1	Organisms need food water and air a way to dispose of waste and an environment in which they can live.	0	4	2
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.	2	2	5
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.	9	21	17
L4.4	When the environment changes some plants and animals survive and reproduce others die or move to new locations.	2	22	18
L4.5	Plants and animals have lifecycles. 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.	0	6	19
L4.6	Plants and animals closely resemble their parents.	0	4	6
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.	6	24	35

Grade 4 Physical Science

Table G3. Content Overlap Ratings for Grade 4 Physical Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
P4.1	Objects and substances have properties. Weight mass and volume are properties that can be measured using appropriate tools.	0	14	0
P4.2	Objects vary in the extent to which they absorb and reflect light and conduct heat thermal energy and electricity.	9	4	5
P4.3	Matter exists in several different states; the most common states 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.	2	4	8
P4.4	Some objects are composed of a single substance, others are composed of more than one substance.	0	5	1
P4.5	Magnets can repel or attract other magnets. They can also attract certain nonmagnetic objects at a distance.	0	11	12
P4.6	One way to change matter from one state to another and back again is by heating and cooling.	2	1	10
P4.7	Heat thermal energy electricity light and sound are forms of energy.	1	6	6
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.	2	6	6
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.	0	5	10
P4.10	Vibrating objects produce sound. The pitch of sound can be varied by changing the rate of vibration.	0	4	8
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).	2	5	24

Table G3. Content Overlap Ratings for Grade 4 Physical Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	0	1	0
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	5	3
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.	5	5	14
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.	0	2	5

Grade 8 Earth and Space Sciences

Table G4. Content Overlap Ratings for Grade 8 Earth and Space Sciences NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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 seven other planets and their moons, as well as smaller objects such as asteroids and comets.	17	30	12
E8.2	Gravity is the force that keeps most objects in the solar system in regular and predictable motion. These motions explain such phenomena as the day, the year, phases of the Moon, and eclipses.	1	21	37
E8.3	Fossils provide important evidence of how life and environmental conditions have changed in a given location.	0	4	6
E8.4	Earth processes seen today, such as erosion and mountain building, make it possible to measure geologic time through methods such as observing rock sequences and using fossils to correlate the sequences at various locations.	3	15	39
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 that are 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.	9	8	10
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.	0	2	5
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.	0	10	8
E8.8	Earth is layered with a lithosphere; a hot, convecting mantle; and a dense, metallic core.	0	4	3

Table G4. Content Overlap Ratings for Grade 8 Earth and Space Sciences NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	0	19	14
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 manmade 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.	0	1	0
E8.11	The Sun is the major source of energy for phenomena on Earth's surface. It provides energy for plants to grow and drives convection within the atmosphere and oceans, producing winds, ocean currents, and the water cycle.	0	8	10
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.	2	11	19
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.	4	31	21
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.	0	10	18
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.	2	21	27

Grade 8 Life Science

Table G5. Content Overlap Ratings for Grade 8 Life Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
L8.1	All organisms are composed of cells, from one cell only 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.	2	9	42
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.	4	7	1
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.	0	20	4
L8.4	Plants are producers; that is, 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.	2	30	13
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.	1	28	2
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.	0	21	27

Table G5. Content Overlap Ratings for Grade 8 Life Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	1	28	43
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.	7	23	7
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.	0	17	4
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.	16	18	15
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 a species is common; most of the species that have lived on the Earth no longer exist.	8	45	49
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.	1	31	7

Grade 8 Physical Science

Table G6. Content Overlap Ratings for Grade 8 Physical Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
P8.1	Properties of solids, liquids, and gases are explained by a model of matter that is composed of tiny particles in motion.	0	23	6
P8.2	Chemical properties of substances are explained by the arrangement of atoms and molecules.	3	8	5
P8.3	All substances are composed of 1 or more of approximately 100 elements. The periodic table organizes the elements into families of elements with similar properties.	0	3	14
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.	7	10	28
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.	1	14	12
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.	5	6	20
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.	7	28	40

Table G6. Content Overlap Ratings for Grade 8 Physical Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	0	3	2
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	5	9
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.	6	15	40
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.	0	2	3
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.	8	19	26
P8.13	Nuclear reactions take place in the Sun. In plants, light from the Sun is transferred to oxygen and carbon compounds, which, in combination, have chemical potential energy (photosynthesis).	0	12	6
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.	2	8	19

Table G6. Content Overlap Ratings for Grade 8 Physical Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	0	7	14
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.	7	12	54

Grade 12 Earth and Space Sciences

Table G7. Content Overlap Ratings for Grade 12 Earth and Space Sciences NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	27	1	0
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.	7	1	2
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.	21	6	2
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.	16	3	5
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.	10	0	2
E12.6	Early Earth was very different from today’s planet. Evidence for one-celled forms of life (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.	15	1	4
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; however, many geological processes, such as the building of mountain chains and shifting of entire continents, take place over hundreds of millions of years.	22	0	2

Table G7. Content Overlap Ratings for Grade 12 Earth and Space Sciences NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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 midocean ridges, and the edges of plates are pulled back down where Earth materials sink into the crust at deep trenches.	38	9	1
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.	10	1	3
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, oceans, seas, and lakes.	30	2	7
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.	15	10	9
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.	6	0	0
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.	7	0	0

Grade 12 Life Science

Table G8. Content Overlap Ratings for Grade 12 Life Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	23	0	2
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.	20	3	6
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.	13	0	7
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).	23	1	5
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.	5	1	1
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.	18	0	0

Table G8. Content Overlap Ratings for Grade 12 Life Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	67	3	7
L12.8	Hereditary information is contained in genes, which are 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.	12	0	4
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.	51	2	24
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.	41	4	6
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.	16	4	2
L12.12	Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched.	13	4	1
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.	58	4	6

Grade 12 Physical Science

Table G9. Content Overlap Ratings for Grade 12 Physical Science NAEP Statements

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
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.	26	1	17
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.	13	3	11
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.	29	1	8
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.	6	0	7
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.	7	0	6
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.	36	1	12
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.	21	0	51

Table G9. Content Overlap Ratings for Grade 12 Physical Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
P12.8	Atoms and molecules that compose matter are in constant motion (translational, rotational, or vibrational).	4	0	1
P12.9	Energy may be transferred from one object to another during collisions.	4	1	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.	29	3	10
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 two relatively light nuclei at extremely high temperature and pressure. Fusion is the process responsible for the energy of the Sun and other stars.	17	2	3
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.	13	0	5
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.	6	0	0
P12.14	Chemical reactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).	11	4	14
P12.15	Nuclear reactions (fission and fusion) convert very small amounts of matter into appreciable amounts of energy.	18	1	5
P12.16	Total energy is conserved in a closed system.	23	7	0
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.	28	6	0
P12.18	Objects undergo different kinds of motion (translational, rotational, and vibrational).	4	0	0

Table G9. Content Overlap Ratings for Grade 12 Physical Science NAEP Statements (Continued)

NAEP Code	NAEP Statement	# State Statements Rated 0	# State Statements Rated 1	# State Statements Rated 2
P12.19	The motion of an object changes only when a net force is applied.	15	6	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=Fnet/m) is independent of the nature of the force.	22	5	0
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=Fnet/m.	41	8	2
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.	19	6	2
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.	22	0	2